le to the Geology of the Morris Area

Grundy County and Parts of Kankakee, Kendall, La Salle, and Will Counties, Illinois

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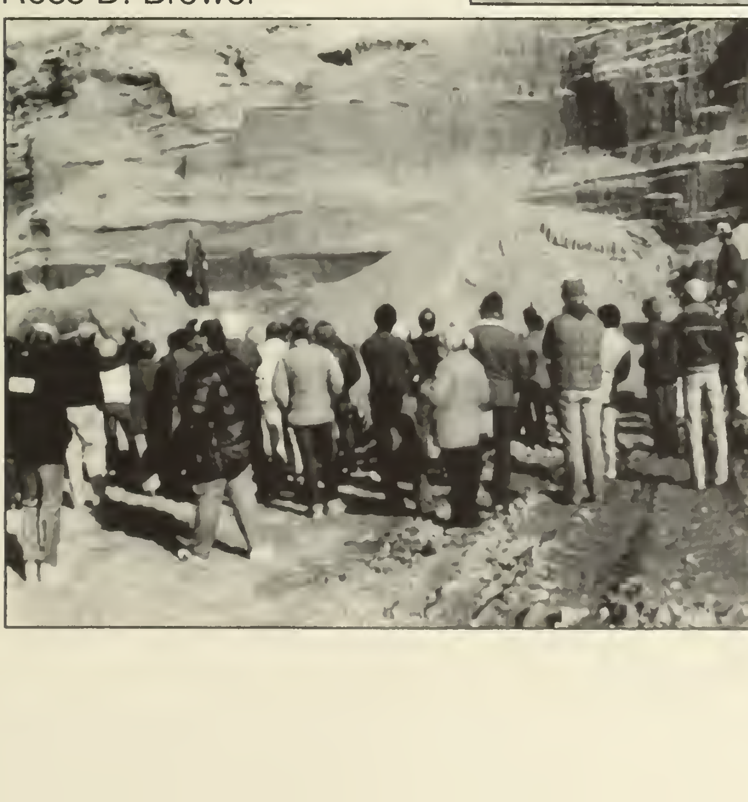

Field Trip Guidebook 1992C, September 19, 1992

Department of Energy and Natural Resources
ILLINOIS STATE GEOLOGICAL SURVEY

Cover photos by D. L. Reinertsen

Sand and gravel pits in northern Illinois.

Geological Science Field Trips The Educational Extension Unit of the Illinois State Geological Survey conducts four free tours each year to acquaint the public with the rocks, mineral resources, and landscapes of various regions of the state and the geological processes that have led to their origin. Each field trip is an all-day excursion through one or more Illinois counties. Frequent stops are made to explore interesting phenomena, explain processes that shape our environment, discuss principles of earth science, and collect rocks and fossils. People of all ages and interests are welcome. The trips are especially helpful to teachers preparing earth science units. Grade school students are welcome, but each must be accompanied by a parent or guardian. High school science classes should be supervised by at least one adult for each ten students.

Field trip guide booklets are available for planning class tours and private outings. For a list, contact the Educational Extension Unit, Illinois State Geological Survey, Natural Resources Building, 615 East Peabody Drive, Champaign, IL 61820. Call (217) 333-4747 or 333-7372.

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ILLINOIS STATE GEOLOGICAL SURVEY
Morris W. Leighton, Chief
Natural Resources Building
615 East Peabody Drive
Champaign, Illinois 61820

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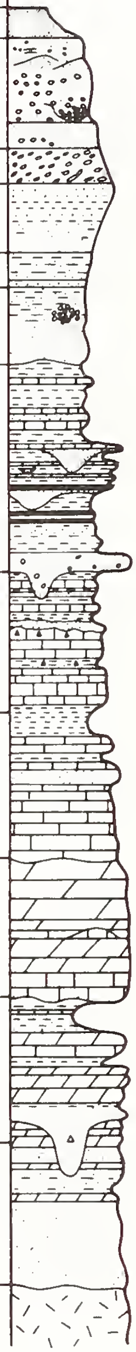
Era		Period or System and Thickness	Epoch	Age (years ago)	General Types of Rocks
CENOZOIC "Recent Life"	Age of Mammals	Quaternary 0-500'	Holocene	10,000	Recent—alluvium in river valleys
			Pleistocene Glacial Age	1.6 m.	Glacial till, glacial outwash, gravel, sand, silt, lake deposits of clay and silt, loess and sand dunes; covers nearly all of state except northwest corner and southern tip
		Tertiary 0-500'	Pliocene	5.3 m.	Chert gravel, present in northern, southern, and western Illinois
			Eocene	36.6 m. – 57.8 m.	Mostly micaceous sand with some silt and clay; present only in southern Illinois
			Paleocene	66.4 m.	Mostly clay, little sand; present only in southern Illinois
MESOZOIC "Middle Life"	Age of Reptiles	Cretaceous 0-300'		144 m. – 286 m.	Mostly sand, some thin beds of clay and, locally, gravel; present only in southern Illinois
PALEOZOIC "Ancient Life"	Age of Amphibians and Early Plants	Pennsylvanian 0-3,000' ("Coal Measures")		320 m.	Largely shale and sandstone with beds of coal, limestone, and clay
		Mississippian 0-3,500'		360 m.	Black and gray shale at base; middle zone of thick limestone that grades to siltstone, chert, and shale; upper zone of interbedded sandstone, shale, and limestone
	Age of Fishes	Devonian 0-1,500'		408 m.	Thick limestone, minor sandstones and shales; largely chert and cherty limestone in southern Illinois; black shale at top
	Age of Invertebrates	Silurian 0-1,000'		438 m.	Principally dolomite and limestone
		Ordovician 500-2,000'		505 m.	Largely dolomite and limestone but contains sandstone, shale, and siltstone formations
		Cambrian 1,500-3,000'		570 m.	Chiefly sandstones with some dolomite and shale; exposed only in small areas in north-central Illinois
ARCHEOZOIC and PROTEROZOIC					Igneous and metamorphic rocks; known in Illinois only from deep wells



~~~~ major unconformity

Generalized geologic column showing succession of rocks in Illinois.
~~~~

MORRIS AREA

The Kankakee Plain, a relatively level surface developed by Wisconsinan *glaciers** less than 15,000 years ago, is the geologic setting for the Morris field trip. Bordering the area on the east, north, and west are prominent ridges, called *moraines*, that formed at the edges of advancing and retreating glaciers. Behind the moraines, meltwater from waning glaciers ponded, forming large lakes in which sediments collected and settled. The old lake bottoms account for the general flatness of the area today. Torrents of meltwater that escaped from these lakes thousands of years ago incised the drainage pattern of the eastern part of the present Illinois River. Glacial and postglacial processes also left rubble bars, sand dunes, clusters of boulders, and related features that can be observed along the field trip route.

Fossilferous *limestones* of Ordovician age lie beneath thin glacial deposits in the northern part of the field trip area. To the south of Morris, what was once an important coal-producing area is underlain by shale that occurs above the Colchester (No. 2) Coal *Member* of Pennsylvanian age. *Concretions* in the shale may contain the famous Mazon Creek plant and animal fossils.

Morris has been an important center of commerce since the days of its settlement in the early 19th century. At least part of its early importance was the result of the construction of the Illinois-Michigan Canal, which was completed in 1848. Although the canal is no longer in use, the city is still a commercial center because the Illinois River has been made navigable through a series of locks and dams. Grain from the surrounding area is loaded into barges at Morris to take advantage of cheap water transportation. Sand is also moved closer to the Chicago market area via barges and towboats. The river is now a part of the Illinois Waterway, which includes the Chicago Sanitary and Ship Canal, the Calumet Sag Channel, and the Des Plaines River. The Illinois River, which begins at the confluence of the Kankakee and Des Plaines Rivers just east of the field trip area, cuts across the area from east-northeast to west-southwest on its way to the Mississippi River, 273 miles away.

On the Morris field trip, we will travel through about one-third of Grundy County and parts of Kankakee, Kendall, La Salle, and Will Counties. The area lies about 55 miles southwest of downtown Chicago.

GEOLOGIC HISTORY

Precambrian Era The Morris area, like most of the midcontinent, has undergone many changes throughout the thousands of millions of years of geologic time. The oldest rocks beneath us on the field trip belong to the ancient Precambrian (Archeozoic and Proterozoic) basement complex (see generalized geologic column on facing page). We know relatively little about these rocks from direct observation because they are not exposed at the earth's surface anywhere in Illinois. Only a few drill holes have been drilled deep enough in Illinois for geologists to collect samples of Precambrian rocks; depths range from more than 4,000 feet in the Morris area to about 13,000 to 17,000 feet in southern Illinois. From the samples, however, we know that these ancient rocks consist mostly of *igneous* and *metamorphic, crystalline* rocks of granitic composition. The rocks formed about 1.5 to 1.0 billion years ago when molten materials slowly solidified deep within the earth. By about 0.6 billion years ago, deep weathering and erosion had exposed the ancient rocks at the surface, forming a landscape probably similar to part of the present Missouri Ozarks. We have no rock record in Illinois for the long interval of weathering and erosion that lasted from the time Precambrian rocks were formed until Cambrian *sediments* were deposited across the older land surface. The interval was longer, however, than the span of geologic time from the Cambrian to the present.

Because geologists seldom see Precambrian rocks except as cuttings from drill cores, they have determined some characteristics of the basement complex by using various techniques such as surface mapping, measurements of the earth's gravitational and magnetic

* Words in italics are defined in the glossary in the back of the guidebook.

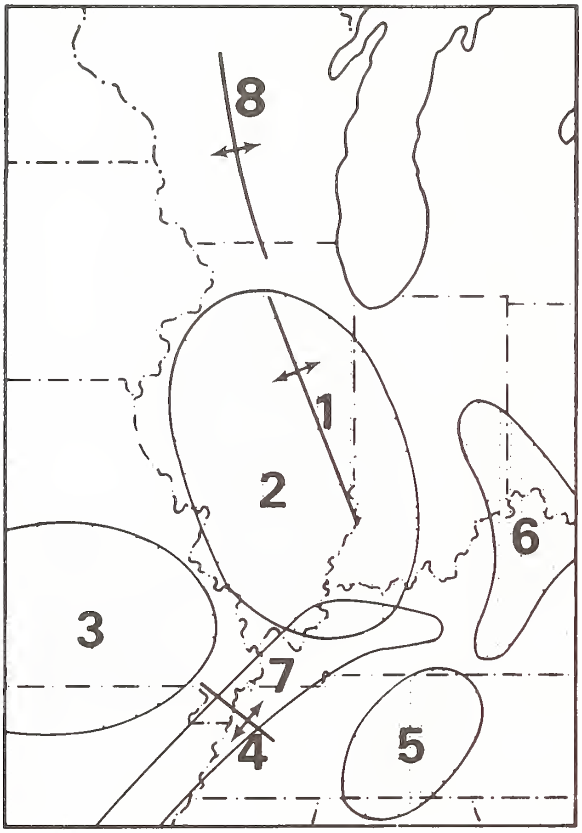


Figure 1 Location of some of the major structures in the Illinois region: (1) La Salle Anticlinal Belt, (2) Illinois Basin, (3) Ozark Dome, (4) Pascola Arch, (5) Nashville Dome, (6) Cincinnati Arch, (7) Rough Creek Graben-Reelfoot Rift, and (8) Wisconsin Arch.

fields, and seismic tests. The evidence indicates that rift valleys similar to those in east Africa formed in what is now southernmost Illinois during the late Precambrian *Era*. These mid-continent rift structures, known as the Rough Creek *Graben* and the Reelfoot Rift (fig. 1), formed when plate tectonic movements (slow global-scale deformation) began to rip apart an ancient Precambrian supercontinent. (Continental collision is going on today as the Indian subcontinent moves northward against Asia, folding and lifting the Himalayas.) The slow fragmentation of this Precambrian supercontinent eventually isolated a new landmass called Laurasia, which included much of what is now the North American continent.

Near the end of the Precambrian Era and continuing until late Cambrian time, from about 570 million to 505 million years ago, tensional forces within the planet apparently caused block faulting (see *fault*) and relatively rapid subsidence of the hilly landscape on a regional scale. This permitted the invasion of a shallow sea from the south and southwest.

Paleozoic Era During the Paleozoic Era, which lasted from about 570 million years ago to about 245 million years ago, the land that now lies under southern Illinois sank slowly; layer after layer of sediment collected in the shallow seas that repeatedly covered the area. Nearly 17,000 feet of sedimentary *strata* accumulated during the 325 million years of the Paleozoic Era. These sediments, when compacted and hardened (*lithified*), and the underlying Precambrian rocks became the *bedrock* succession.

From middle Ordovician time about 460 million years ago, until the end of the Permian Period (and the Paleozoic Era) about 245 million years ago, the midcontinent (now Illinois, Indiana, and western Kentucky), sank more slowly than it did earlier. Repeatedly, sediments poured into a broad trough or embayment covering the area and overflowed into surrounding areas as well. Shells of marine animals, muds, silts, and sands deposited in those seas over millions of years were gradually buried and lithified into solid rocks of limestone, dolomite, shale, siltstone, and sandstone.

Earth's thin crust has been frequently flexed and warped in various places by forces of compression and tension that developed within the earth at various times. Movements of the land surface, flexing upward then downward, recurred over millions of years and caused the seas to periodically drain from the region, then slowly return. When the sea floors were uplifted and exposed to weathering and erosion by rain, wind, and streams, some previously deposited strata were eroded. Consequently, not all geologic intervals are represented in the rock record of Illinois (see generalized geologic column, page iv).

The geologic column Figure 2 shows the succession of rock strata that a drill bit would be likely to encounter in the Morris area. (The oldest *formations* are at the bottom of the column.) Figure 3 shows an interpretation of the general configuration and structure of sedimentary rock strata in Illinois. Sedimentary rocks in Illinois are classified by using formation names. Because of great similarities in appearance and composition, some sequences of formations are generally classified and mapped together in a unit called a *group*. Some formations contain thin, distinctive units called members.

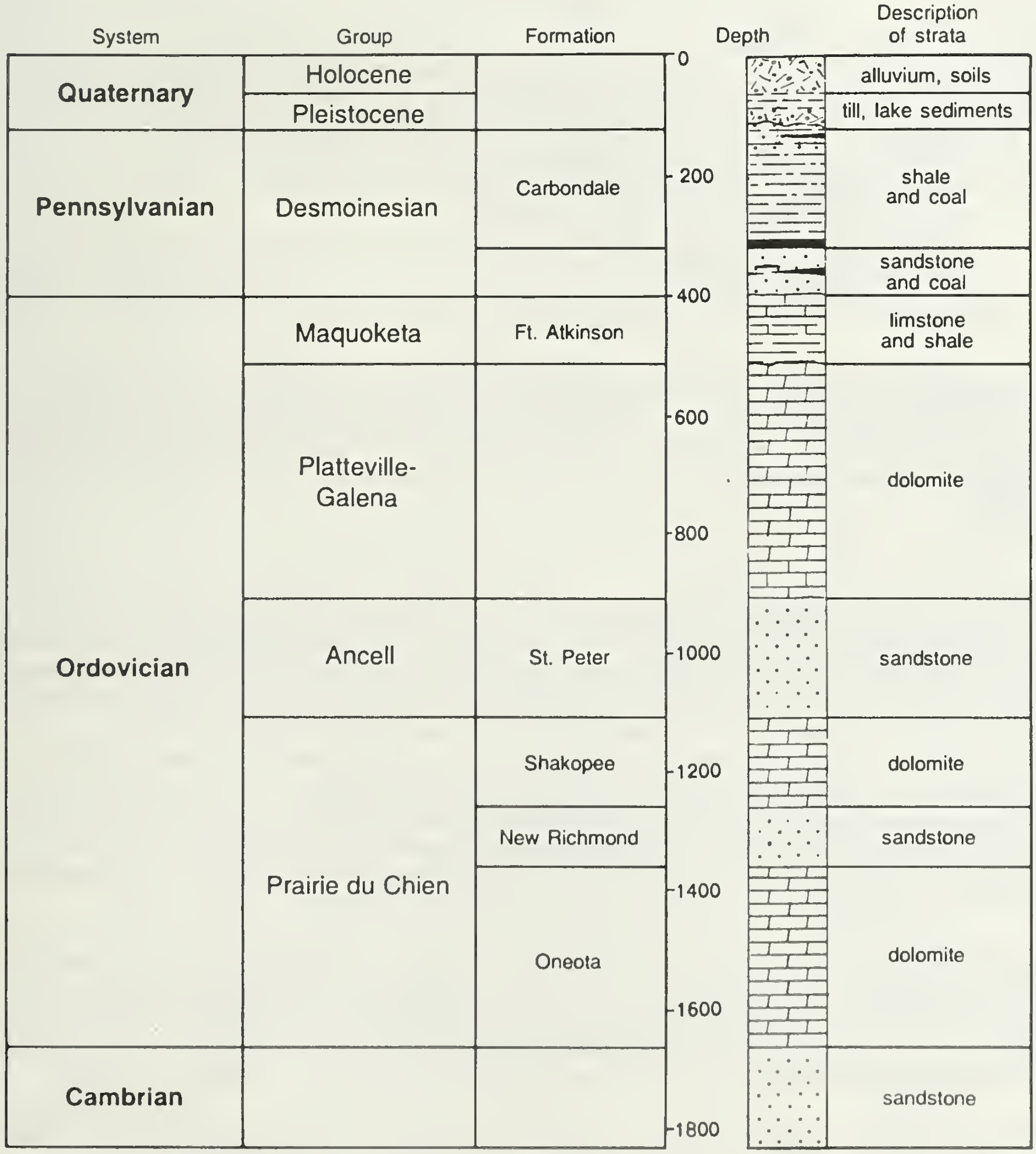


Figure 2 Generalized columnar section of the rocks underlying the Morris area.

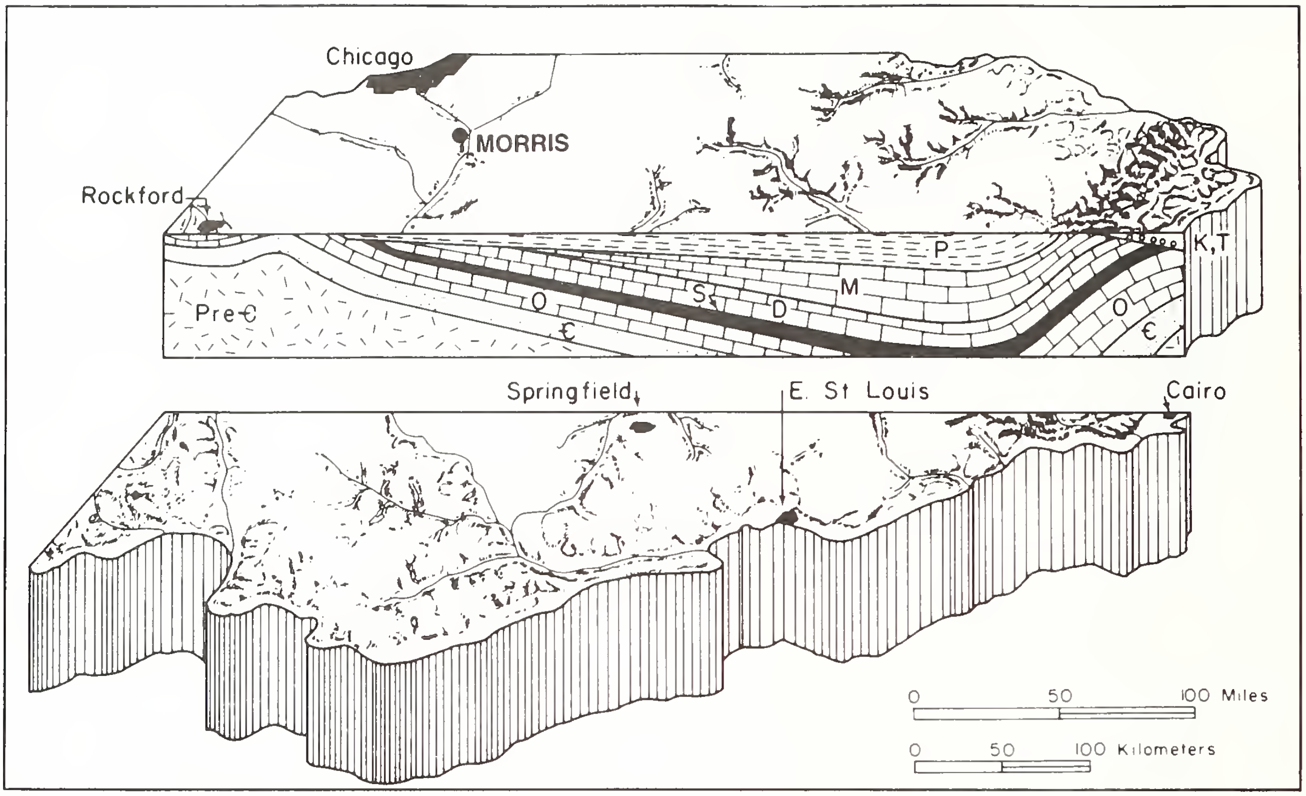


Figure 3 Stylized north-south cross section shows the structure of the Illinois Basin. The thickness of the sedimentary rocks has been greatly exaggerated to show detail, and the younger, unconsolidated surface deposits have been eliminated. The oldest rocks are Precambrian (Pre-C) granites that form a depression filled with layers of sedimentary rocks of various ages: Cambrian (C), Ordovician (O), Silurian (S), Devonian (D), Mississippian (M), Pennsylvanian (P), Cretaceous (K), and Tertiary (T). The scale is approximate.

Many of the formations in groups have conformable contacts, which means that no significant interruptions took place between deposition of the sediments of one formation and the sediments of another (fig. 2). In some cases, composition and appearance of the rocks change significantly at the contact between two formations, even though the fossils in the rocks and the relationships between the rocks indicate that deposition was essentially continuous; this type of contact is called a *disconformity*. In other cases, the lower formation was subjected to weathering that partly eroded it before sediments of the overlying formation were deposited. Also, fossils and other evidence in the formations indicate a significant gap between the time when the lower unit was deposited and the time when the overlying unit was laid down. This type of contact is called an *unconformity*. If the lower strata were tilted and eroded before the overlying strata were deposited, the contact is called an angular unconformity. (Unconformities are shown as undulating lines across the rock unit column in many geologic columns.)

Geologic framework of the field trip area In Grundy County, the field trip area is underlain by 4,000 to 4,500 feet of Paleozoic *sedimentary* rocks, ranging from deeply buried rocks of late Cambrian age (about 523 million years old) to surface exposures of middle Pennsylvanian age (about 312 million years old). The oldest Paleozoic rocks exposed in the area are Ordovician in age; they formed from sediments that accumulated up to perhaps 455 million years ago.

Evidence from nearby areas strongly suggests that Paleozoic strata younger than Ordovician and older than Pennsylvanian once covered the area. For example, Silurian rocks are encountered 15 miles east and about 60 miles west of Morris, a fact indicating that these strata may have once been here, but were completely removed by erosion.

Mississippian strata, also missing here, have been identified along with Pennsylvanian strata in cores from holes drilled into the structure known as the Des Plaines Disturbance (fig. 4, Emrich and Bergstrom 1962) near the western suburb of Des Plaines about 55 miles north-northeast. Mississippian strata may have been deposited and eroded away before Pennsylvanian sediments spread over the area. Perhaps 5,000 feet or more of Late Pennsylvanian (see appendix, *Depositional History of the Pennsylvanian Rocks*) and younger strata once covered northern Illinois (Damberger 1991), according to indirect evidence based on the *rank* of coals in La Salle and Grundy Counties. Millions of years of erosion have removed these rocks, leaving some large gaps in the rock record.

Figure 5 shows where the major bedrock units in Illinois would be located if all glacial deposits were scraped off. Bedrock exposures in the field trip area are limited essentially to outcrops along the Illinois River, some of its tributary streams, highway and railroad cuts, and quarries. Generally, rocks of the Ordovician *System* (figs. 2 and 5) occur at or just below the surface over the northern part of the trip area, while strata of the Pennsylvanian System occur at or just below the surface in the western and southern parts of the area.

As mentioned before, the depositional history of the region is linked with tectonic events. During Late Mississippian and Early Pennsylvanian time, the east coast of the present North American continent was colliding with another continent, creating the Appalachian Mountains. Several major structural features formed in the midcontinental region, including the La Salle *Anticlinal* Belt (extending from La Salle County to around Lawrence County). During this time, the area just north of here was uplifted, faulted, and warped along the Sandwich Fault Zone.

The Morris area is situated about 40 miles east-northeast of the crest of the La Salle Anticlinal Belt and about 18 miles southwest of the Sandwich Fault Zone. Apparently, these major structures only influenced the attitude of the strata in a general way, as the rocks here are essentially flat-lying with gentle dips of less than 1° to the southeast.

Mesozoic and Cenozoic Eras Although Paleozoic rocks are present nearly everywhere in Illinois, no evidence indicates that younger sediments accumulated during the long interval between deposition of the latest Pennsylvanian rocks and deposition of the Pleistocene glacial *drift*. This "sub-Pleistocene unconformity," the bedrock surface in Illinois, truncates all Tertiary, Cretaceous, and Paleozoic rocks down to the Upper Cambrian rocks exposed at the bedrock surface in the Sandwich Fault Zone. Mesozoic rocks are absent from the stratigraphic record in most parts of the state, whereas Cenozoic materials cover most of the state.

In the field trip area, except for the glacial deposits, no rocks younger than those of the Pennsylvanian Period are present. The tectonic history (the history of the earth's crustal movements) of the region during the past 570 million years is only partly known and the rest must be inferred from evidence present in other places.

During the Mesozoic and Cenozoic Eras but before the onslaught of glaciation 1 to 2 million years ago, the land surface of this area was exposed to weathering and erosion. Deep valley systems were carved into the gently tilted bedrock formations. The rugged *topography* was then considerably subdued by the repeated advance and retreat of glaciers, which scoured and scraped the old erosion surface. All except the Precambrian rocks were exposed to erosion.

Quaternary geology About 1.6 million years ago, during the Pleistocene *Epoch* (commonly called the Ice Age), continental glaciers flowed slowly southward from the northern to the mid-latitudes (see appendix, *Pleistocene Glaciations in Illinois*). Several times, ice sheets covered parts of the region we know as Illinois. The last of these glaciers melted from the northeastern area of the state about 13,500 years before the present (B.P.), near the close of Wisconsinan time. Continental glaciers reached their southernmost extent in North America during the Illinoian glaciation about 270,000 years B.P. Evidence of the southern limit of glaciation can be observed in northern Johnson County, about 260 miles south-southwest of Morris (fig. 6).

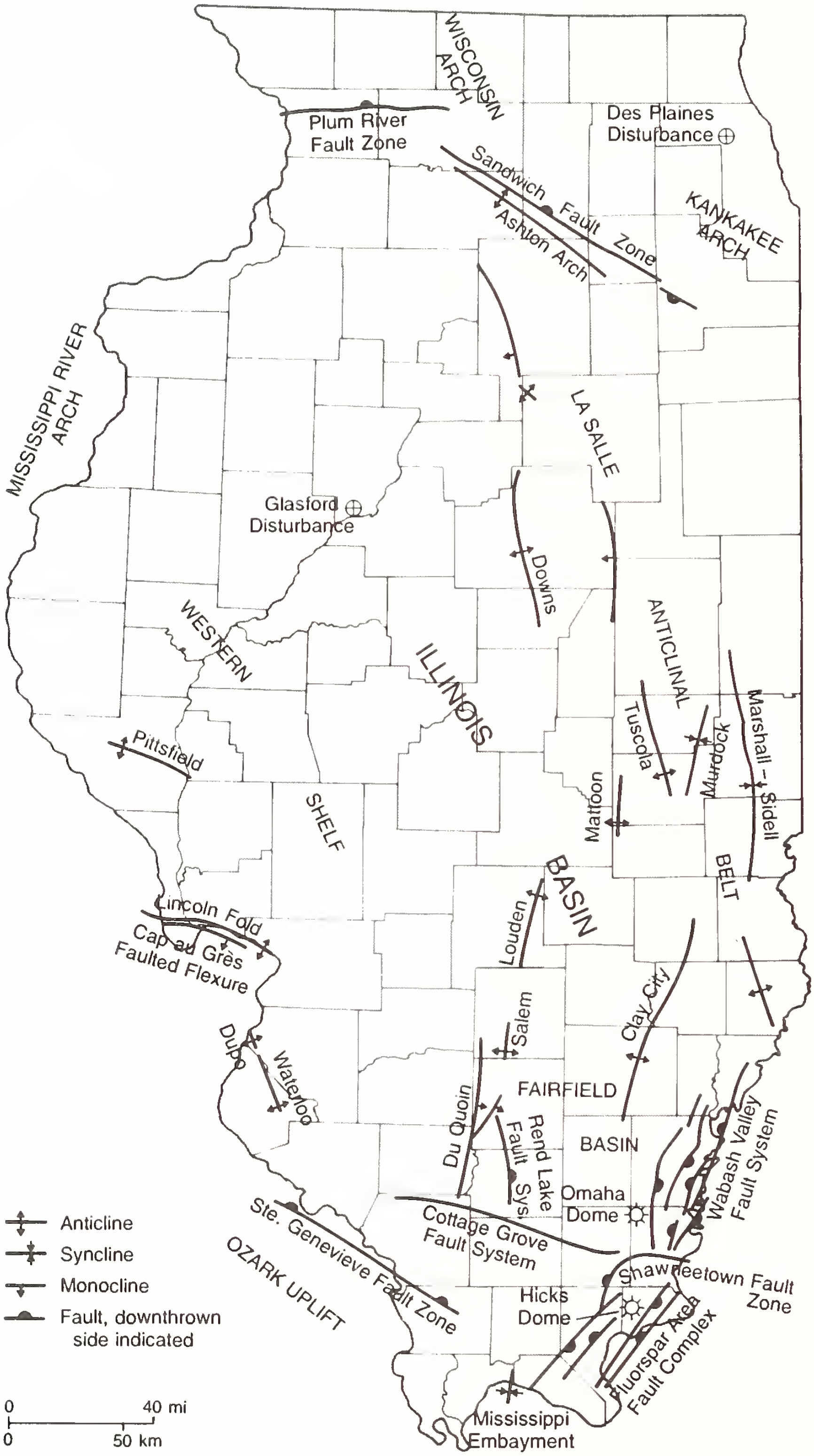


Figure 4 Major structural features in Illinois.

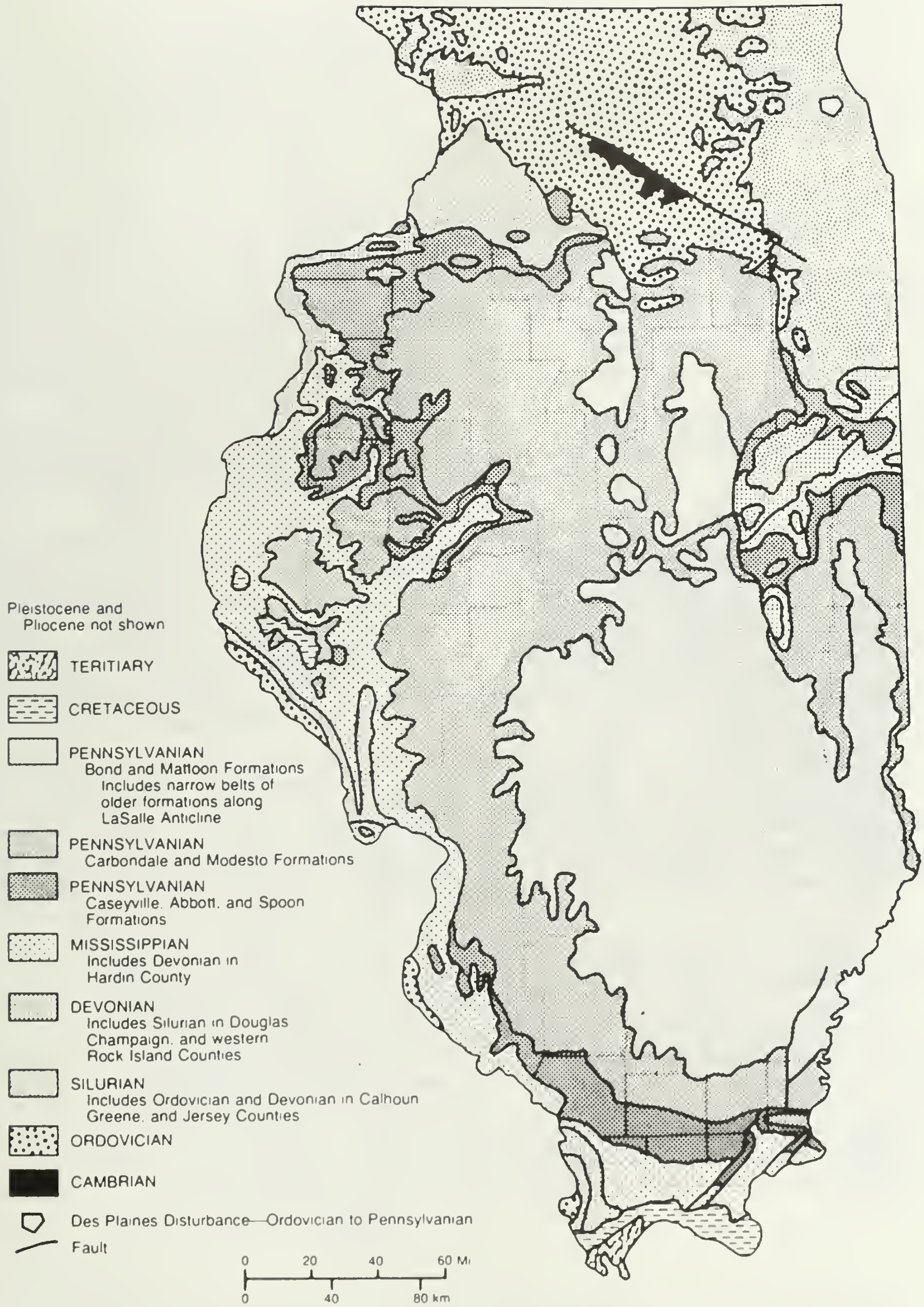


Figure 5 Bedrock geology beneath surficial deposits in Illinois.

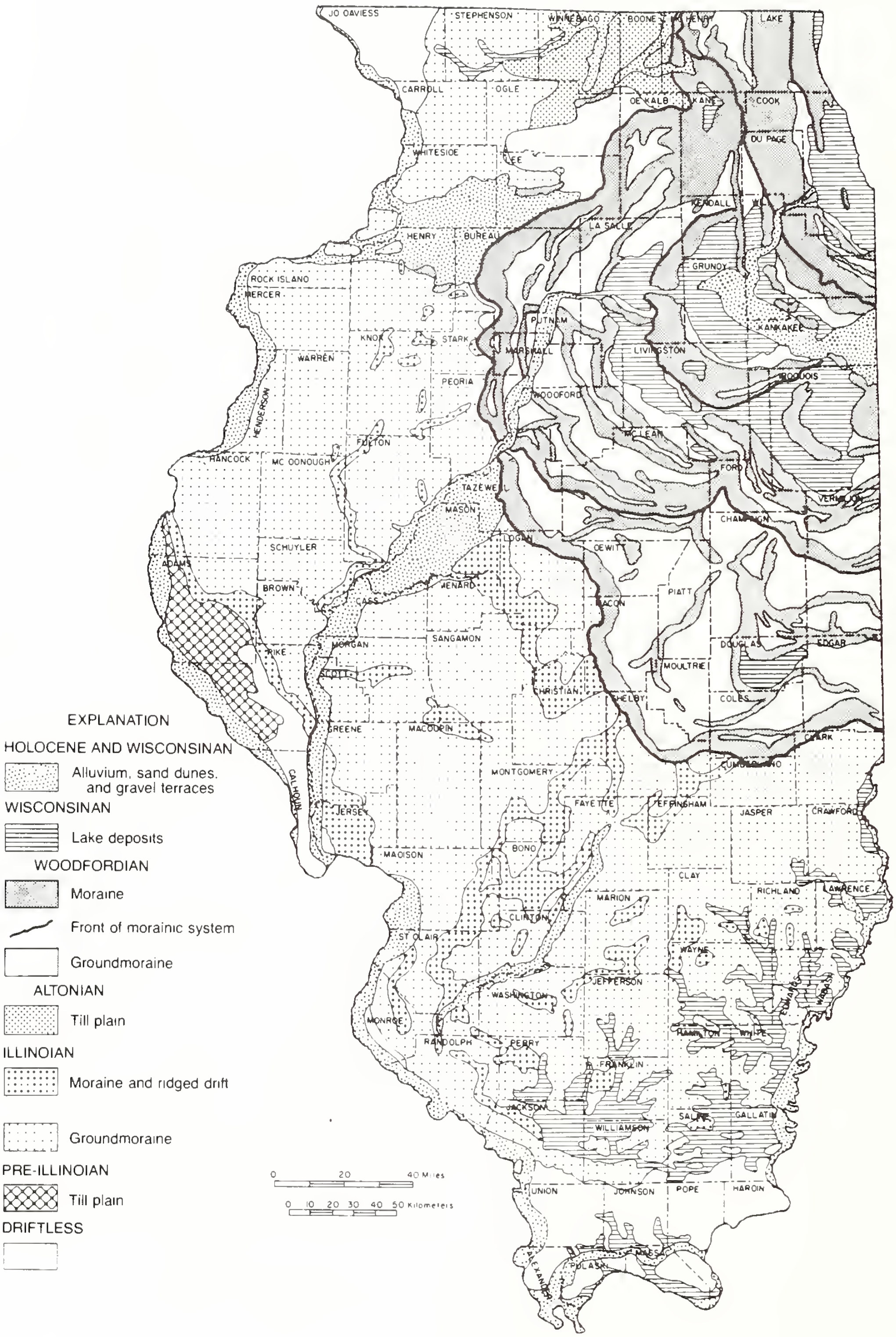


Figure 6 Generalized map of glacial deposits in Illinois (modified from Willman and Frye 1970).

Until recently, glaciologists assumed that ice thicknesses of 1 mile or more were likely for these glaciers; however, the ice may have been, at most, about 2,000 feet thick in the Lake Michigan Basin and on the order of 700 feet thick across most of the land surface. That conclusion is based on studies of present ice sheets, mainly in Greenland, as applied to ancient ice masses: (1) the degree of consolidation and compaction of rock and soil materials under the ice is proportionate to the mass/thickness of the ice; and (2) the geometry, configuration, and flow of ancient ice masses can be inferred from the data on present ice sheets and ice caps. Adding to the evidence is the amount of rebound that has occurred in the materials of the Lake Michigan Basin, since it was compressed under the mass of glacial ice.

The ice of various glaciations was active and thick enough to scour and remove part of the bedrock surface. Much of the evidence for pre-Illinoian and early Illinoian glaciations is missing from the northern part of our state; it was removed by the effects of the subsequent Wisconsinan glaciation. The last major glacial advance, the Wisconsinan Woodfordian, began about 25,000 to 22,000 years B.P. Ice from an accumulation center (where Labrador now lies) slowly flowed southward through the Lake Michigan Basin to form the Lake Michigan Glacial Lobe that spread out across the region that became northern Illinois. Figure 7 shows the classification of the Pleistocene materials in central-northern Illinois.

The thickness of sediments deposited by the glaciers (glacial drift) ranges from a few feet to somewhat more than 50 feet over much of the field trip area. Thicknesses greater than 250 feet occur in the Marsailles Morainal Complex in the western part.

The landscape in the Morris area is largely the result of deposition and erosion following the Woodfordian Substage of the Wisconsinan Glacial Stage. The Woodfordian surface and deposits have been modified further by erosion and deposition during postglacial time. The Woodfordian glacier reached its maximum westward extent about 21,000 years B.P., when it reached a point, now lying beyond Hennepin in Putnam County, and blocked the ancient Mississippi River from its ancestral course south of the "great bend" of the present Illinois River. After establishing the Mississippi in its modern course, the ice front melted back, forming a series of *end moraines* to the east that roughly parallel the shore of the present Lake Michigan.

Morris occupies an area of low *relief* called the Morris Basin, which lies east and south of the high Marseilles Morainal Complex and west of the Minooka Moraine. Glacial lakes occupied parts of the Morris Basin several times during the Woodfordian and are responsible for the general flatness of the area. The lakes were formed by the meltwater that ponded between the high moraines to the north and west and the melting front of the glacier to the east. The deposits of these lakes consist of finely layered clays and silts, beach sands and gravels, *delta* complexes (such as Central Ridge), and coarse rubble bars.

More recent deposits in the field trip area are windblown silt (called *loess*, which rhymes with "bus") and sand. The loess was winnowed and blown from the Wisconsinan *outwash* materials left along *floodplains* of the rivers transporting glacial meltwaters to the sea. Each summer, floods of sediment-laden meltwater deposited layers of mud, silt, sand, and gravel across the floodplains of the rivers. With the coming of winter, melting decreased and floodplains that were water-covered during the summer were exposed to bitter, drying winds. The cold winds picked up huge clouds of dust from the floodplains and spread the fine material across the land. The Mississippi River was a major source of this loess, but other floodplains were local sources. Loess thickness ranges up to about 4 feet in the western part of the area and thins to 2 feet or less in the east. The loess helped to subdue the topography of the eroded glacial materials.

GEOMORPHOLOGY

Physiography

The physiographic contrasts between various parts of Illinois are due to several factors, including the topography of the bedrock surface, the extent of the various glaciations, differences in the thickness of the glacial deposits, differences in age of the uppermost glacial drift, and the effects of erosion on the land surface.

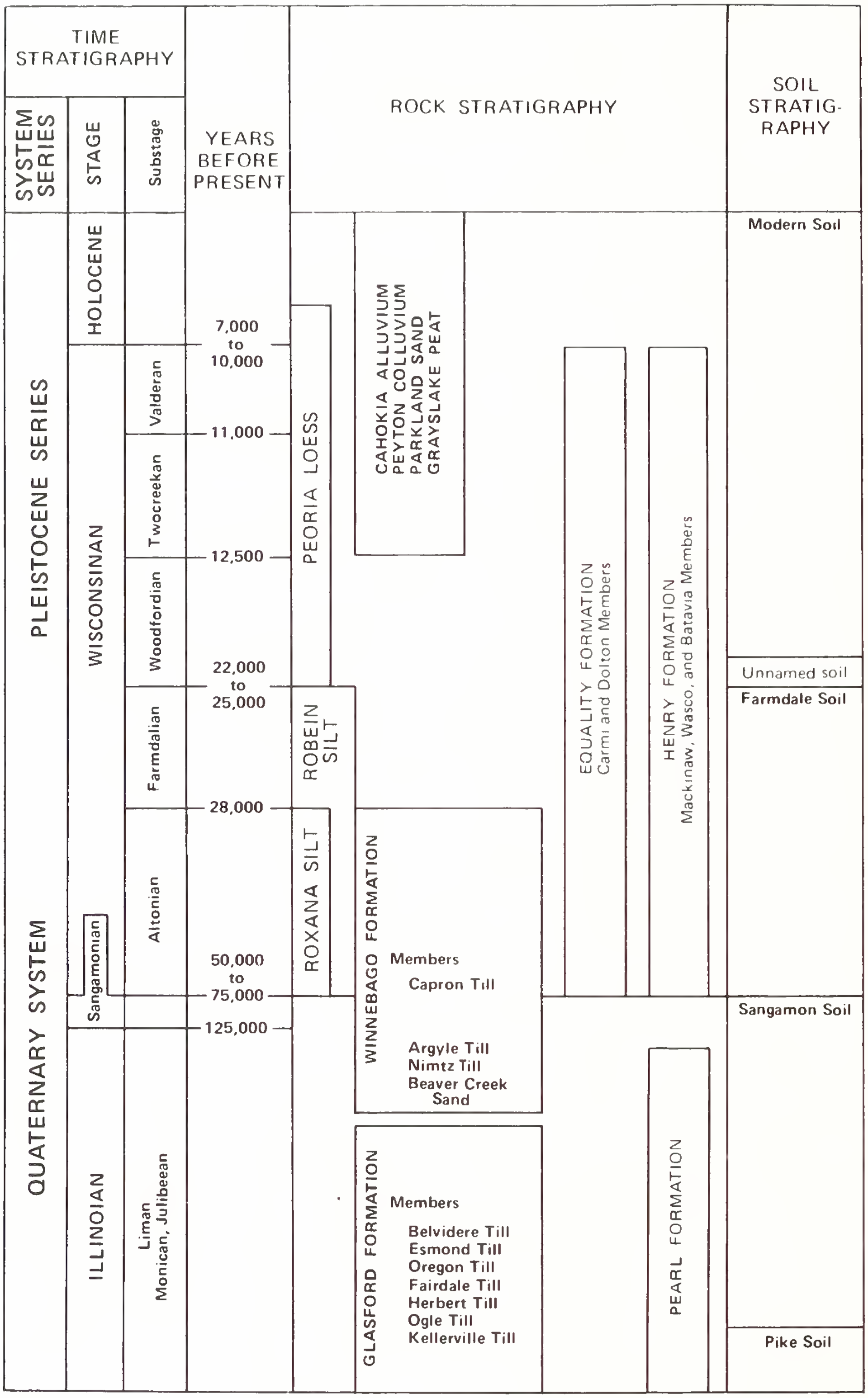


Figure 7 Stratigraphic classification of Quaternary deposits of central-northern Illinois.

Figure 8 Physiographic divisions of Illinois.

The Morris field trip area is situated in the northern Illinois part of the Till Plains Section, the division of the Central Lowland Physiographic Province (fig. 8) that embraces about four-fifths of Illinois. This section is characterized by broad *till* plains that are relatively uneroded (a youthful stage of erosion), in contrast to the maturely eroded Dissected Till Plains on older driftsheets in Iowa. In Illinois, the Section has seven subdivisions: the Bloomington Ridged Plain, Galesburg Plain, Green River Lowland, Kankakee Plain, Mt. Vernon Hill Country, Rock River Hill Country, and the Springfield Plain.

Morris is located in the northwest part of the Kankakee Plain. Leighton and others (1948) describe the Kankakee Plain as a level to gently undulatory surface with low morainic islands, glacial terraces, torrent bars, and dunes. It is partly *fluviolacustrine* in origin, although the lakes that covered it were temporary expansions of glacial floods and did not extensively alter its surface by deposition or erosion, except along the courses of strong currents. It could be considered an intermorainic basin, floored with ground moraine and bedrock.

The Kankakee Plain is enclosed by the Minooka, Manhattan, and Iroquois Moraines on the northeast and east and by the Ransom and Chatsworth Moraines on the west and south.

Drainage

Drainage is poor throughout the area. Low-*gradient* streams follow slight depressions that were left between glacial deposits, then scoured out by meltwaters. The two major streams of the Kankakee Plain, the Kankakee and the Des Plaines, occupy glacial *sluiceways* entrenched in Silurian dolomites near Kankakee and Joliet. The drift is thick to thin; near Kankakee it scarcely conceals the bedrock surface.

Morris is located on the Illinois River about 10 miles west of its headwaters, the confluence of the Kankakee and Des Plaines Rivers. On the north side of the Illinois River, Nettle Creek flows east and south into it from the Ransom Moraine. Saratoga Creek also flows east, eventually emptying into the river. The south part of the field trip area is drained by Waupecan Creek and Mazon River, which flow north into the Illinois River.

Relief

The highest land surface elevation along the Morris field trip route is slightly more than 765 feet mean sea level (msl) and located at Stop 3. The lowest elevation is about 484 feet msl, the water surface of the Illinois River in the vicinity of Morris. Thus the maximum relief along the field trip route is about 281 feet. The maximum local relief is slightly more than 130 feet from the intersection of North 37th Road and County Line Road (La Salle and Kendall Counties) and the bottom of the glacial sluiceway 0.9 mile northeast.

MINERAL RESOURCES

Groundwater

A mineral resource frequently overlooked in assessing an area's natural resource potential is *groundwater*. Its availability can be essential for orderly economic and community development. Groundwater is the water supply for more than 5 million people who live in 88% of the state. The other half of the population, mainly people living in Chicago, rely on surface water supplies such as Lake Michigan. Consequently, studies of groundwater resources are an integral part of the research and service at the Illinois State Geological Survey (ISGS).

Groundwater resources are obtained from underground formations called aquifers. *Aquifer* materials (sand and gravel, sandstones, fractured rocks) are saturated and permeable enough to transmit usable quantities of water to wells or springs. The source of groundwater is precipitation—rainwater or melting snow—that enters or infiltrates the soil. Soil moisture that is not evaporated or used by plants percolates or seeps downward (because of gravity) and replenishes the groundwater supply; this is called recharge. Recharge for most shallow wells occurs within a few miles of the well.

The water-yielding capacity of an aquifer is evaluated by constructing wells into it. Test wells are pumped and water samples collected to determine the quality and quantity of the water supply.

Northern Illinois is underlain by three major types of aquifers that are differentiated from one another on the basis of their *hydrogeologic* properties and the sources of recharge. The aquifer materials are (1) unconsolidated glacial deposits, (2) sedimentary bedrock units, and (3) crystalline Precambrian rocks (which have no significant aquifers in Illinois).

The unconsolidated materials overlying bedrock are recharged by local precipitation; they are susceptible to surface contamination.

The upper part of the bedrock sequence in this area consists of jointed and fractured, thin sandstone and limestone units that lie directly beneath the glacial drift and generally have low yields. These rocks are also recharged by local precipitation. The only filtering of recharge water is through the overlying glacial deposits. Where the glacial units are thin or absent and the bedrock is exposed at the surface, recharge enters directly into the rock units, and there is little, if any, filtering of contaminants.

Bedrock units that are important to the area as aquifers consist generally of bedrock formations that directly underlie the glacial drift in the northern part of the area. Here, the formations consist mostly of Ordovician dolomites that contain water in open joints and fractures. Because groundwater occurs in open channels in these rocks, the aquifers are especially susceptible to contamination where they have little overlying protection, such as fine-grained, relatively impermeable materials.

The principal water-yielding horizons in the deeper bedrock aquifer groups are mostly made up of relatively porous sandstones. They receive most of their recharge from regions where they are exposed at the surface or where they directly underlie the glacial drift, miles to the north of the field trip area. They also receive some of their recharge from overlying rocks that are slowly permeable. The water in the deep bedrock aquifers has been in contact with the rocks that make up the aquifer for a relatively long time and has dissolved some of the minerals in those rocks. Generally, the water in the deep bedrock aquifer groups has a fairly high content of dissolved solids.

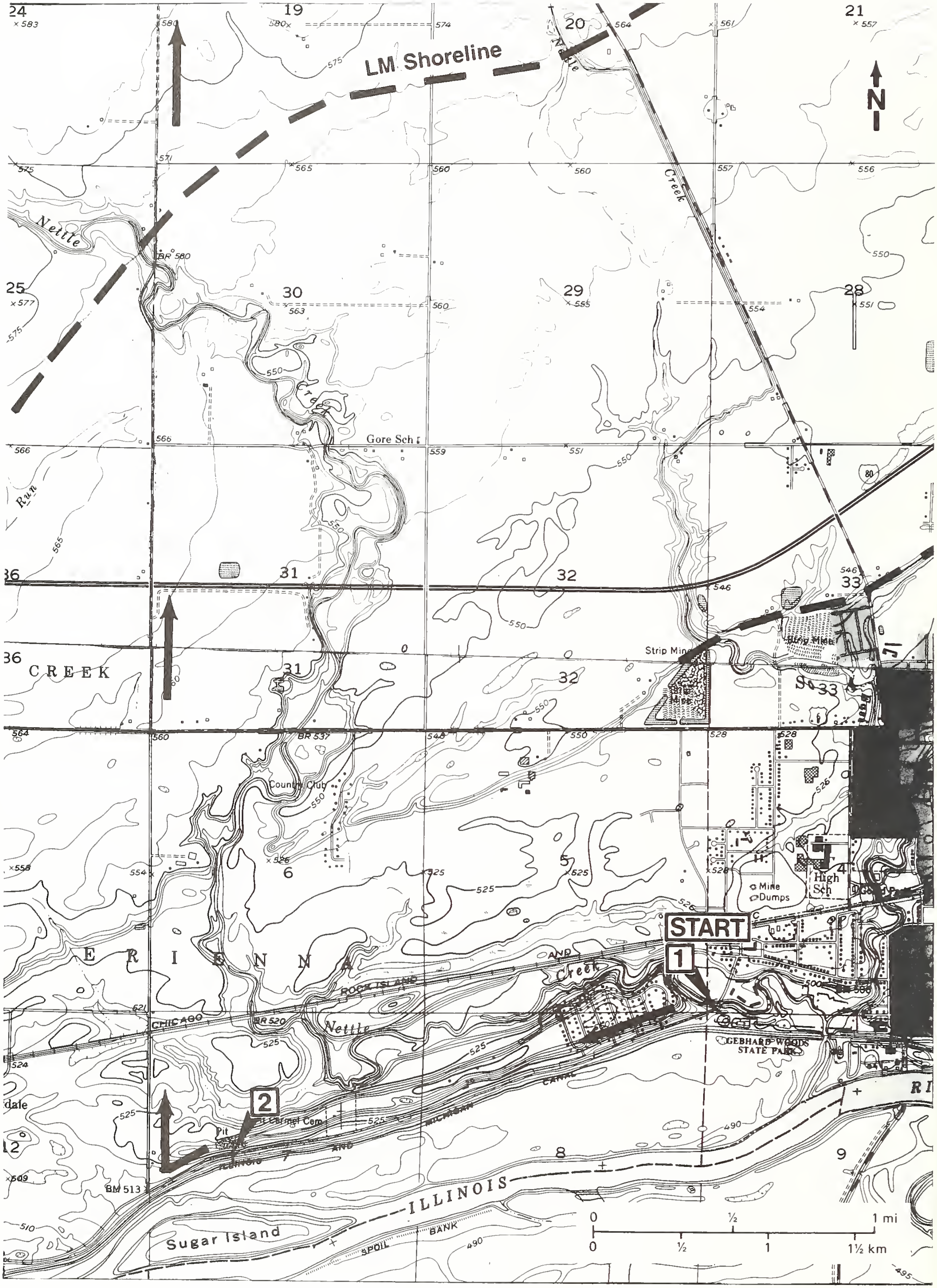
Mineral Production

Of the 102 counties in Illinois, 98 reported mineral production during 1990, the last year for which totals are available. The total value of all minerals extracted, processed, and manufactured in Illinois was $2.9 billion (Samson, in press).

Grundy County ranked 66th among Illinois counties reporting mineral production during 1990. Sand and gravel were the primary minerals extracted. Illinois ranks seventh in the production of sand and gravel with a total extraction of 32.4 million tons valued at $104.7 million at the pit. In 1988, 107 companies operated 157 pits at 143 operations in 55 counties.

Kendall County ranked 65th among Illinois counties reporting mineral production during 1990. Stone, sand, and gravel were the minerals extracted. Kendall County lies in U.S. Bureau of Mines (USBM) District 3 along with 22 other eastern downstate counties, nine of which produce stone. In 1989, total Illinois stone production was estimated at 62.7 million tons valued at $283.1 million; reported tonnage placed Illinois fourth among 48 states reporting production of crushed and broken stone. Also in 1989, the latest year for which data are available, 54 of Illinois' counties produced stone; 103 companies operated 178 quarries. Stone is used primarily for construction aggregate, especially as road-base stone, but it is also used in chemical and agricultural production.

In 1989, Vulcan Material Company had 118 plants in the United States, and their combined output made them the largest producer of crushed and broken stone in the country. In Illinois, however, they ranked second with nine operations. Material Service Corporation ranked eighth largest among the nation's producers and first in Illinois. The 18 Illinois counties that make up USBM District 1 encompass the most densely populated areas of the state, including both Chicago and Rockford. The 34.9 million tons of crushed and broken stone produced by the 89 operations in the district constitute almost 55% of the total production in the state in 1989.



LM Shoreline
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Creek
Gore Sch
Strip Mine
Country Club
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ERIENNA
ROCK ISLAND
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AND
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GUIDE TO THE ROUTE

Assemble in the parking area of Gebhard Woods State Park on the southwest side of Morris (NE NW NW NW Sec. 9, T33N, R7E, 3rd P.M., Grundy County; Morris 7.5-Minute Quadrangle [41088C4]*). We'll start calculating mileage from the parking lot entrance.

You must travel in the caravan. *Do not drive ahead of the caravan!* Please keep your headlights on while in the caravan. Drive safely but stay as close as you can to the car in front of you. Please obey all traffic signs. If the road crossing is protected by an emergency vehicle with flashing lights and flags, then obey the signals of the ISGS staff directing traffic. When we stop, park as close as possible to the car in front of you and turn off your lights.

Some stops on the field trip are on private property. The owners have graciously given us permission to visit on the day of the field trip only. Please conduct yourselves as guests and obey all instructions from the trip leaders. So that we may be welcome to return on future field trips, please do not litter or climb on fences. Leave all gates as you found them. These simple rules of courtesy also apply to public property. If you use this booklet for a field trip with your students, youth group, or family, you must (because of trespass laws and liability constraints) get permission from property owners or their agents before entering private property.

STOP 1 Assemble on the towpath just south of the parking lot for a discussion of the Illinois and Michigan Canal Corridor (SE NW NW NW Sec. 9, T33N, R7E, 3th P.M., Grundy County; Morris 7.5-Minute Quadrangle [41088C4]).

The feasibility of digging a canal to connect Lake Michigan with the Illinois River, via the Des Plaines and Chicago Rivers, was recognized early during the settlement of Illinois. As early as 1673, explorers Joliet and Marquette had noted this possibility.

Illinois created a Canal Commission in 1823 to oversee the design and construction of the Illinois and Michigan Canal. In 1829, Congress authorized the State to build a canal to link Lake Michigan and the Illinois River at an estimated cost of $4 million. Work began in 1836, but the 1837 panic affected the project, and construction was stopped in 1839. Work was resumed, but in 1843, after an expenditure of nearly $5 million, the original lake-level canal program was abandoned in favor of a cheaper, shallow-cut canal with locks. The canal, finally completed in 1848 at a cost of $6.5 million, extended 96 miles from La Salle to a point just north of Interstate 55 at Ashland Avenue. The canal originally was 60 feet wide and 6 feet deep and had 15 locks to adjust water level for the differences in elevation along its route. This was the first complete inland water route from the east coast to the Gulf of Mexico.

Illinois mineral producers were among the important users of the canal. Coal was easily shipped to eastern markets, and stone and sand and gravel were shipped from place to place along the waterway. Lumber, salt, agricultural implements, and steel tracks for railraod construction were imported to Illinois via the canal. The Illinois and Michigan Canal was instrumental in turning Chicago into a major transportation hub by linking it to the industrial east.

Packet boats carried both local and through passengers on the canal for only a few years. The highest use, 3,411,504 passengers, occurred in 1851. Imagine the activity around here at that time! In 1853, however, the first railroad was completed and the packet boats were sold because they could not compete with the lower fares and faster service of the trains. Competition from the railroad and the larger Chicago Sanitary and Ship Canal in the 1890s

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* The number in brackets [41088C4] after the topographic map name is the code assigned to that map as part of the National Mapping Program. The state is divided into 1° blocks of latitude and longitude. The first two numbers refer to the latitude of the southeast corner of the block; the next three numbers designate the longitude. The blocks are divided into sixty-four 7.5-minute quadrangles; the letter refers to the east-west row from the bottom and the last digit refers to the north-south column from the right.

finally put the Illinois and Michigan Canal out of business about 1907. In 1933, the Illinois Waterway was completed and the I and M Canal was closed to navigation.

An act of the Illinois Legislature in 1841 redrew the boundaries of La Salle County to form Grundy County. The county seat, Morris, was centrally located on the Illinois and Michigan Canal. The town grew slowly until the canal was completed; by 1850, the population exceeded 500.

In 1984, Congress enacted legislation establishing the Illinois and Michigan Canal National Heritage Corridor to recognize the area's unique contributions to the nation's development. Cultural, historic, natural, recreational, and economic resources of the area are to be retained, enhanced, and interpreted for the benefit of all.

Leave Stop 1 and return to your car for the remainder of the trip.

Miles to next point	Miles from start	
0.0	0.0	STOP: 1-way at park entrance. TURN LEFT (southwest) on Old Stage Road.
0.7	0.7	The largest tree in the state was located to the left on the south side of the canal until a 1992 summer storm blew it down. The tree was an eastern cottonwood more than 120 feet tall. The trunk circumference was more than 27 feet and the crown spread exceeded 110 feet.
0.7	1.4	Mount Carmel Cemetery to the right. Continue ahead (southwest).
0.35+	1.75+	Entrance to Nettle Creek Sand Company on the right. PARK along roadside as far off the road as you can safely. WALK to the entrance gate; do NOT climb any fences.

STOP 2 We will see the inside of the ridge exposed in the pit of the Nettle Creek Sand Company, which produces sand and gravel for construction purposes and use as fill sand. (Entrance: S edge SE SW SE NW Sec. 7, T33N, R7E, 3rd P.M., Grundy County; Morris 7.5-Minute Quadrangle [41088C4]).

All pit faces consist of crossbedded sand. Crossbedding is the arrangement of sediment layers in which minor beds incline in straight or slightly concave lines at various angles, with some sets of beds cutting directly across other sets. Crossbedding generally occurs when swift, local currents of water change direction rapidly, a situation that may occur in streams or deltas. The Illinois River Valley served as a major outlet for meltwater from glaciers that lay to the northeast, so we can easily imagine that this location was occupied again and again by meltwater streams characterized by braiding. A process of successive branching and rejoining of stream channels, braiding occurs when a stream is carrying a greater load of sediment than it can efficiently transport downstream.

Some of the crossbeds dip up to 30° from the horizontal, and scalloped channels have been scooped out in some places and filled with sand. Some beds exhibit sediment that becomes finer or coarser from bottom to top, indicating rapid changes in stream velocity and, therefore, in the amount and size of sediment that could be carried.

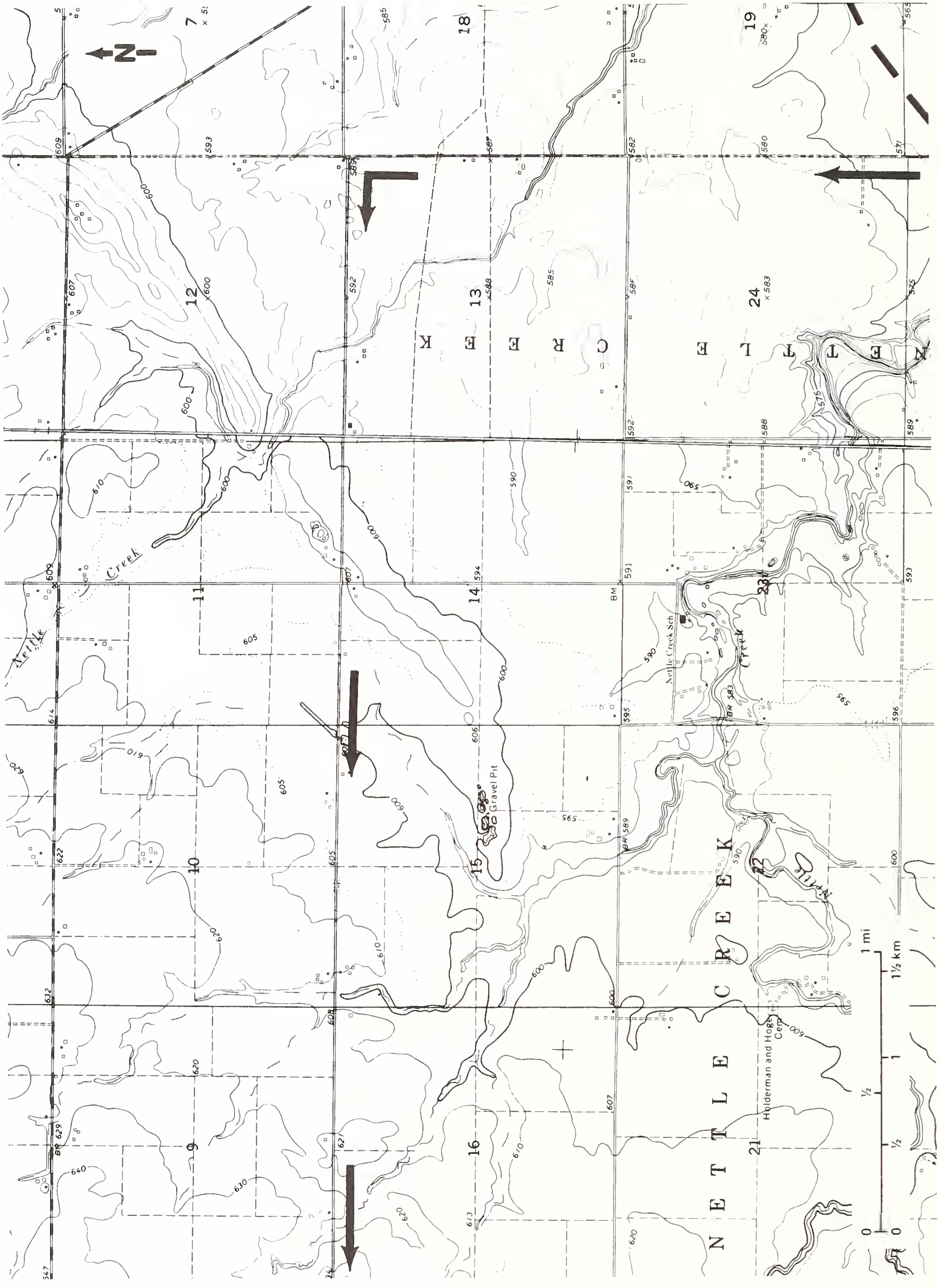
One prominent feature of the south-facing wall is the massive bed about 2 to 5 feet thick near the top. The bed serves as a home to numerous swallows, as is apparent from the many holes appearing in the unit. Although this unit looks like loess, closer examination reveals that the unit is finely bedded and probably consists of very fine sand and some silt. Its top and bottom

contacts are irregular; it appears to thicken in the northeast face and to disappear toward the east and southeast.

Another interesting feature is the presence of several massive blocks of pink Tiskilwa *diamicton* (probably *till*) slumping down the north face. These blocks were probably melted out from the margin of the Tiskilwa glacier. Their presence suggests that at least part of the outwash exposed in this pit is related to Tiskilwa glaciation. Chunks of pink diamicton have become detached and rolled downslope. Because of their relatively high clay content, they maintained some cohesiveness, but picked up an armor of coarser material such as sand and pebbles on the outside. These "armored till balls" are quite common in this pit and range from less than 1 inch to several inches in diameter. They are shaped from almost perfectly round balls to long oblong pieces resembling cigars. They can be easily broken apart so that the internal structure of the ball can be examined.

Another interesting feature is the irregular cementation of some layers of coarser material, generally high up on the east face. The cementation occasionally causes problems for the mining operation because it generally does not have the equipment to break up these large pieces. The cementation probably occurs when groundwater, moving downward rapidly through the coarser material, encounters a fine grained zone, where it loses velocity and precipitates some of its dissolved minerals around the coarser grains. In this case, the cement appears to be calcite. Diluted hydrochloric acid reacts violently on these slabs.

0.0	1.75+	Leave Stop 2 and CONTINUE AHEAD (southwest).
0.2	1.95+	Prepare to turn right ahead.
0.1+	2.05+	TURN HARD RIGHT (north) onto Saratoga Road (3000 W).
0.1+	2.2+	Cross crest of ridge on which Stop 2 is located.
0.4+	2.65+	CAUTION: single-guarded Iowa Interstate (IAIS) Railroad track.
0.1	2.75+	The surface material on the left side of the road has been reworked considerably to construct a new golf course with homes around the edge.
0.3	3.05+	The break in slope marks where the road crosses the glacial Lake Cryder (LC on route map) shoreline.
0.25	3.3+	Notice how flat the upland is here. It is part of an old lake bottom.
0.4+	3.75	STOP: 2-way. CONTINUE AHEAD (north) across US 6 (6000N)
0.5+	4.25+	I-80 overpass.
0.3	4.55+	Notice how dark the soils are in this area. Just beyond the farm on the left, the soil is quite sandy and blows easily in the wind. Ditches fill with drifting soil at times. The shoreline of glacial Lake Morris (LM on route map) is about 0.75 mile to the west.
0.85	5.4+	Cross Nettle Creek. CONTINUE AHEAD (north).
0.15	5.55+	Cross glacial Lake Morris shoreline.
1.2	6.75+	STOP: 2-way at crossroad. Cross Nelson Road (9000 N) and CONTINUE AHEAD (north).
0.25+	7.05	CAUTION: narrow culvert, East Fork Nettle Creek.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NETTLE CREEK
Nettle Creek
Nettle Creek Sch
Gravel Pit
Holderman and Hoge Cem
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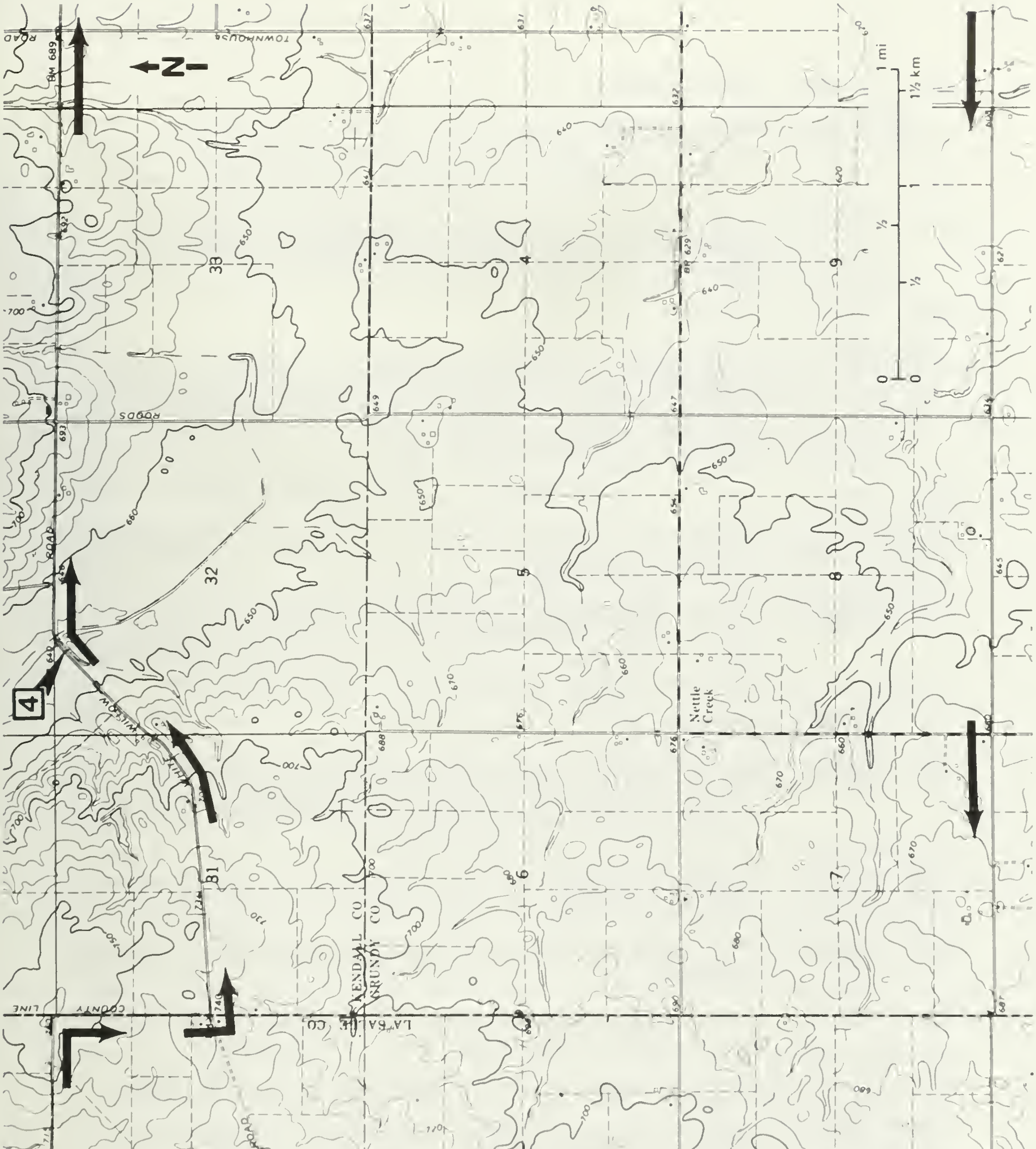
1½ km


N
KENDALL CO
GRUNDY CO
LA SALLE CO
Nettle Creek
TOWNHOUSE ROAD
WOODS ROAD
COUNTY LINE
TELEPHONE ROAD
1 mi
1½ km
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31
32
33
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8
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10
12
36

0.2+	7.25+	Pipeline crossing.
0.15+	7.45	Pipeline crossing.
0.3+	7.75+	STOP: 2-way at crossroad. TURN LEFT (west) on Airport Road (10000 N).
0.15	7.9+	About 0.5 mile to the right is a series of elongate sand and fine gravel ridges (collectively called Central Ridge) that extends from northeast to southwest for several miles.
0.5+	8.4+	Cross East Fork Nettle Creek.
0.45+	8.9+	We are starting to ascend the gentle slopes of Central Ridge. Notice that the soils along the ridge are more sandy than those on either side of the ridge, which may be a large, poorly developed complex of overlapping ice-contact deltas. When the ice stood where we are, these deltas were forming in glacial Lake Lisbon to the right.
0.25+	9.2+	Cross crest of Central Ridge into the area of glacial Lake Lisbon.
0.05+	9.25+	STOP: 2-way at Scott School Road (4500 W). CONTINUE AHEAD (west) on Airport Road (10000 N).
0.1	9.35+	To the left, notice the sand stringers near the bottom of the slope. This series of ridges of Central Ridge is now on our left and dies out about 1.5 miles to the southwest. To the right in the distance, is the northern crest of the Marseilles Morainic System developed on the Ransom Moraine.
0.1	9.45+	Pipeline crossing.
1.25	10.7+	Notice again how relatively flat the land is in this vicinity. The small tributaries cut into this upland surface, but they are relatively shallow. As we continue west, the topography is more rolling because we are coming up the back slope of the Ransom Moraine.
1.0+	11.75+	CAUTION: T-road from right, Roods Road (7000 W). CONTINUE AHEAD (west) on Airport Road.
1.0+	12.75+	STOP: 2-way; Nettle Creek Road (8000 W). CONTINUE AHEAD (west) on Airport Road.
0.9	13.65+	STOP: 2-way at La Salle Road (9000 W and E 30th Road). JOG RIGHT and then LEFT (west) onto North 34th Road in La Salle County.
0.25	13.9+	As we continue west, notice how the topography becomes more rolling.
0.75+	14.65+	STOP: 1-way at T-road intersection, Seneca Road. TURN RIGHT (north) on La Salle County Jighway 25.
0.5	15.15+	To the north and slightly to the left, is a large telephone relay tower, which is sitting on the crest of the Ransom Moraine.
1.55-	16.7	Angled T-road from left is called Telephone Road (N35.01st Road). CONTINUE AHEAD (north) and prepare to park.
0.15+	16.85+	PARK along the roadside as far off the pavement as you can safely. CAUTION: FAST TRAFFIC. Do NOT cross the road and do NOT enter the field at the top of the exposure.

STOP 3 We'll examine the Yorkville Till on the Ransom Moraine in this low roadcut and view some glacial features from this vantage point (Ctr W edge NW SW SW Sec. 36, T35N, R5E, 3rd P.M., La Salle County; Stavanger 7.5-Minute Quadrangle [41088D5]).

The radio tower just to the southwest of this stop is located near the crest of the Ransom Moraine at an elevation of approximately 770 feet msl. In clear weather, you get an unobstructed view of the landscape for miles around, particularly to the east and northeast, where you can see across the Morris Basin to the Minooka Moraine on the east side of the basin.

The soil here is developed in loess and in the underlying silty and clayey Yorkville Till Member of the Wedron Formation. The loess is only about 3 to 4 feet thick in this region. The Yorkville diamicton consists of a mixture of clay, silt, sand, some pebbles, and rarely, a few cobbles and boulders. Regionally, the matrix of this diamicton (the sand, silt, and clay material surrounding the larger pebbles) averages 10% sand, 40% silt, and 50% clay. The dominantly silty clayey texture of the diamicton indicates that the Yorkville ice probably picked up and carried fine grained, lake-bottom sediments from the Lake Michigan Basin.

Where it has not yet been altered by weathering processes, the Yorkville is gray. Here, where it has been exposed to the atmosphere, it has oxidized to brown, and it is also slightly coarser in texture. The glacier was probably stagnating and reworking some of its rock debris as it melted, causing mudflows and slumps of saturated, ground-up rock debris and some loss of the finer grained material. Also, weathering and soil-forming processes may have translocated some of the finer material downward.

Numerous pebbles are scattered over the exposure here. Some were probably thrown over to the roadsides by the movements of heavy machinery during road construction. Others may have been in the original rock debris melted out by the ice and left as a "lag gravel" on the surface of the exposure, as the surrounding clay, silt, and sand slowly eroded away and washed downslope under repeated precipitation through the years. Dolomite and shale are the most common types of rock found as pebbles within the Yorkville.

A study of the clay mineral composition of the Yorkville till throughout the Morris Basin and the Marseilles Morainic System (Killey 1982) reveals a distinct mineralogical unit, consisting of less illite and a different dolomite-calcite ratio than exists in the lower Yorkville, in the upper part of the Yorkville diamicton in this region. These mineralogical differences are consistent enough to allow mapping of the upper unit across the Morris Basin and in the surrounding moraines. The study concludes that, after the lower Yorkville diamicton was deposited, the Yorkville ice underwent a minor meltback and then readvanced into the Morris Basin with a concurrent change in source material.

Interestingly, the northern limit of the upper unit coincides with the northeast-southwest-trending Central Ridge in the Morris Basin, which was interpreted by earlier ISGS geologists to represent deltas formed by a temporary stand of the ice front in the basin at the time Lake Lisbon existed. Central Ridge consists of bands of medium and fine gravel and coarse sand dipping 10° northwest. One can imagine a tongue of relatively thin glacial ice extending across the basin, and meltwater flowing off the edge, depositing coarser material into these northwest-dipping beds.

0.0	16.85+	Leave stop 3 and CONTINUE AHEAD (north). USE CAUTION when pulling back on the road. To the north, note the striking contrast in the topography compared to that of the area you have been travelling across to get here. The surface is very rolling and hummocky, as is typical of a Woodfordian moraine in northeastern Illinois.

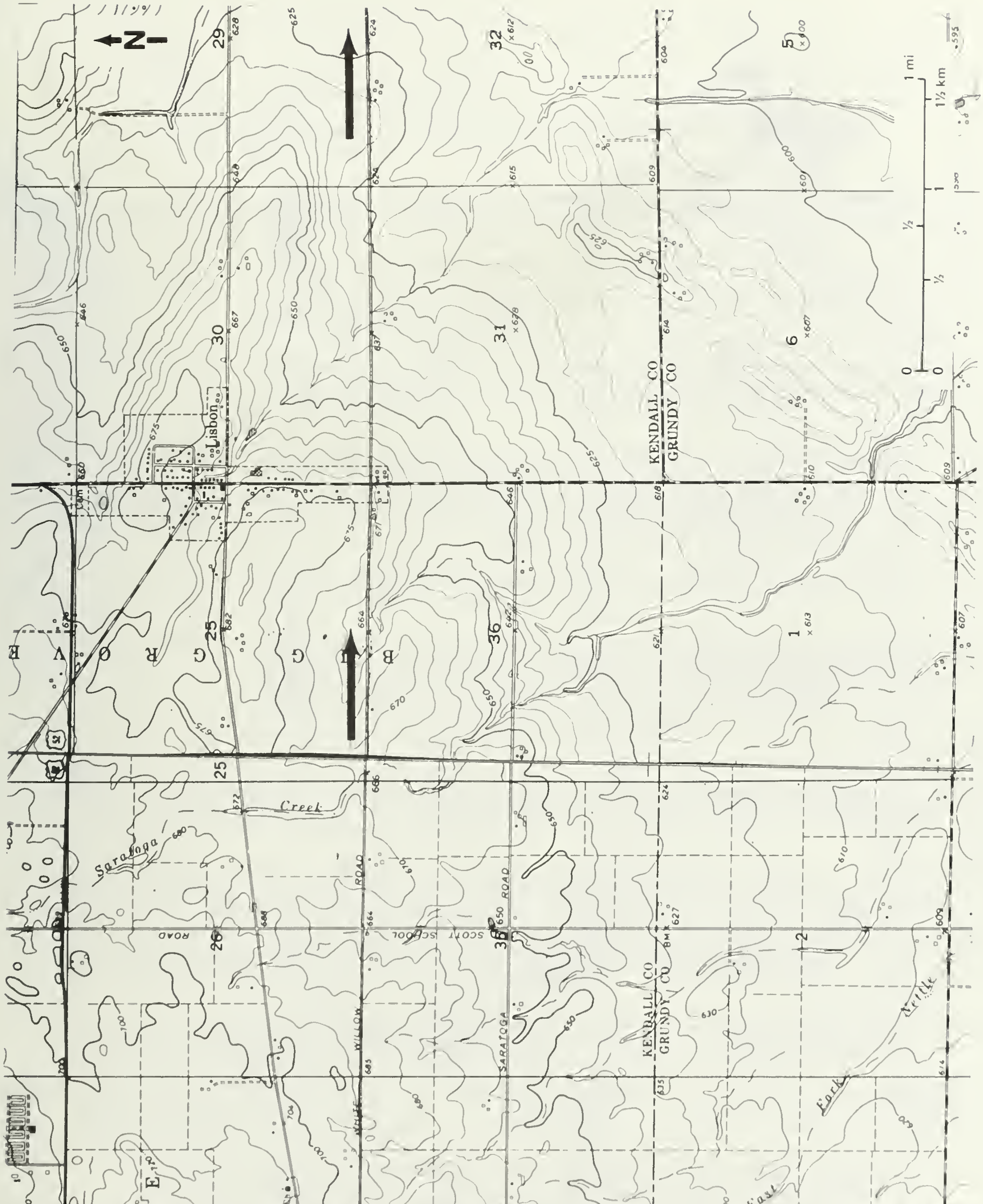
0.7	17.55+	Prepare to turn right ahead.
0.1+	17.65+	TURN RIGHT (east) on N37th Road.
1.0	18.65+	STOP: 1-way at T-road intersection, La Salle Road (County Line Road). The stop sign is face down in the ditch on the right by the boulder, which appears to have been split by the mechanical weathering process of freezing and thawing. TURN RIGHT (south).
0.5	19.15+	TURN LEFT (east) on White Willow Road (18000 W) into Kendall County.
0.4	19.55+	As we start down the slope into the sluiceway, we have an excellent view towards the right (east and southeast) across the Morris Basin.
0.6	20.15+	We are driving down into the *sluiceway*, the glacial drainageway that cut through the Marseilles Morainic System and carried meltwater northward into the Fox River.
0.3+	20.45+	PARK along the roadside as far off the roadway as you safely can. Do NOT park on the bridge or block fence openings.

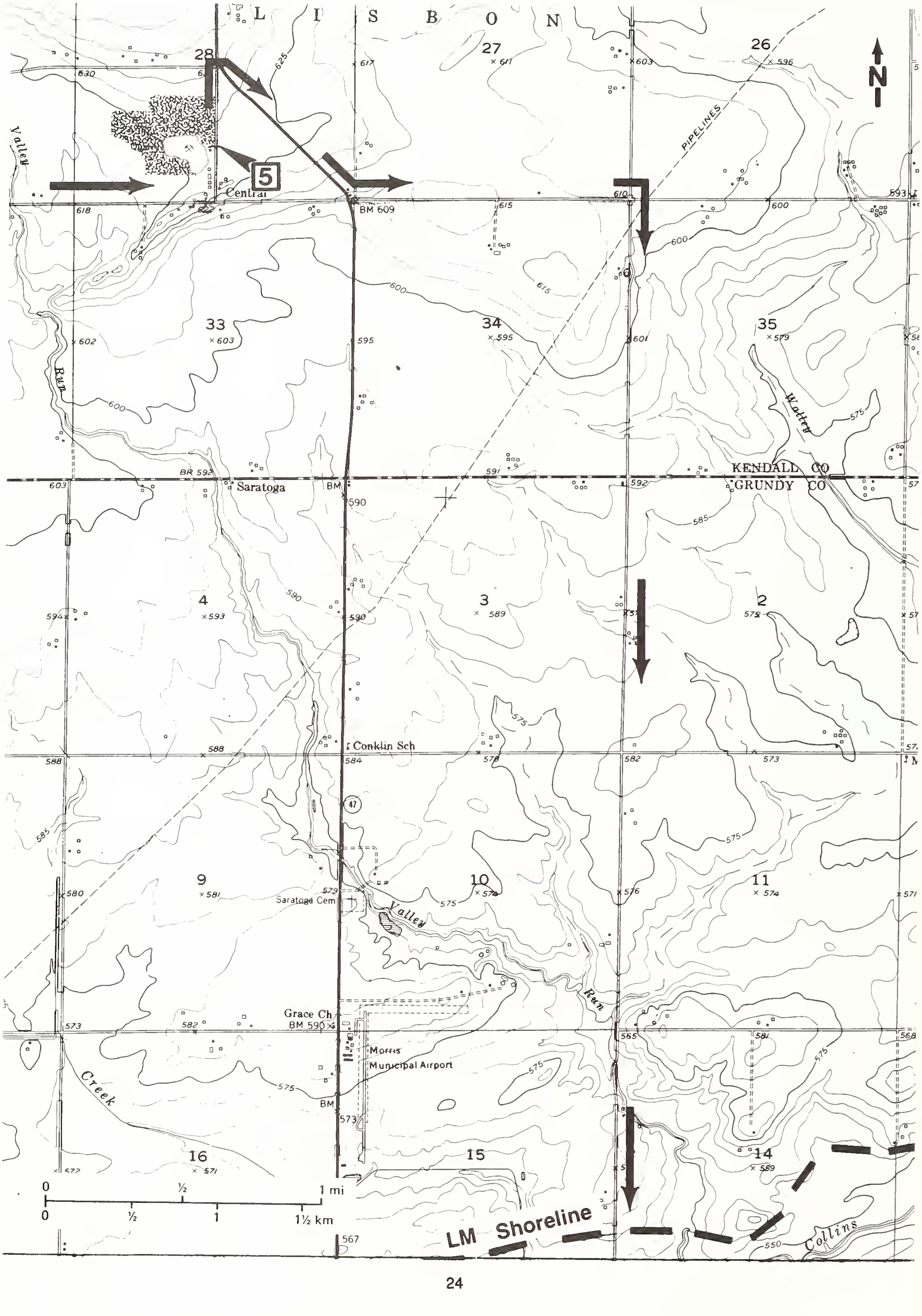
STOP 4 From the north side of the road, we'll view the glacial sluiceway that eroded the Marseilles Morainic System (NW NW NE NW Sec. 32, T35N, R6E, 3rd P.M., Kendall County; Stavanger 7.5-Minute Quadrangle [41088D5]).

You have now descended about 130 feet from the crest of the Marseilles Morainic System to the center of a prominent but narrow valley that is interpreted to have been eroded through the morainic system by meltwater flowing off the retreating glacier. Actually, several meltwater channels cut entirely through the Marseilles Morainic System along its length. Looking toward the northwest, you can see the relatively steep valley walls at the channel's narrowest point. To the southwest, however, the valley quickly widens out into the Morris Basin. It is difficult to imagine that the small intermittent stream now occupying this channel cut a valley of this size.

Instead, imagine a lake that formed when meltwater surged off the ice front to the south and became dammed between the ice front and the moraine. A history of successive postglacial lakes dammed between the Marseilles Moraine and the retreating ice front was inferred by ISGS geologists, who observed distinctive shoreline features at various elevations within the Morris Basin. The first, Lake Lisbon, with a maximum elevation of about 700 feet above msl, was presumed to have formed during retreat of the ice front from the northwestern part of the Ransom Moraine while the ice still extended up the inner slope of the moraine that now lies near the present Illinois River (see discussion of Central Ridge at Stop 3). At its maximum, the lake would have risen up the backslope of the Ransom Moraine to an elevation near that of the white house you see on the east side of the valley. Anyone standing here at that time would have been about 60 feet under water! Eventually the meltwater topped a sag in the moraine crest and eroded this channel through the morainic system. The views at Stops 3 and 4 give some idea of the sheer size and immensity of the ice sheets that formed much of today's landscape in Illinois.

0.0	20.45+	Leave Stop 4 and CONTINUE AHEAD (east).
0.05+	20.5+	Cross the bridge and CONTINUE AHEAD (east) on White Willow Road.
0.15+	20.7	T-road intersection from left, Stephens Road. CONTINUE AHEAD (east) on White Willow Road.
0.5+	21.2+	STOP: 2-way at Roods Road (16000 W) and CONTINUE AHEAD (east) on White Willow Road (17000 S).


N
Lisbon
KENDALL CO
GRUNDY CO
Saratoga
Creek
SCOTT SCHOOL
ROAD
WILLOW
SARATOGA
TOWNHOUSE
East
Fork
Little
1 mi
1½ km



L I S B O N
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596
PIPELINES
Valley
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Central
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BM 609
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Walley
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BR 592
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Saratoga
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KENDALL CO
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½
1
1½ km
567
LM Shoreline
550
Collins

1.0+	22.2+	Cross East Fork Nettle Creek.
0.25	22.45+	STOP: 2-way at Townhouse Road. CONTINUE AHEAD (east) on White Willow Road.
0.2+	22.7+	T-road from left, Joliet Road. CONTINUE AHEAD (east) on White Willow Road.
1.0	23.7+	STOP: 2-way at Scott School Road. CONTINUE AHEAD (east).
0.5+	24.25	Cross Saratoga Creek. The topography here is controlled by bedrock, which is very close to the surface.
0.95+	25.2+	STOP: 2-way at Lisbon Road (12000 W). The village of Lisbon is just to the left, a little more than 0.25 mile. CONTINUE AHEAD (east) on White Willow Road (17000 S).
1.5	26.7+	To the left are large white piles of crushed stone from the Avery Brothers Quarry. The large pile behind the barns just east and south is the overburden, which is stockpiled for future reclamation of the quarry site.
0.9+	27.65	Cross the crest of Central Ridge again. This locality is called Central.
0.1	27.75	CAUTION: heavy traffic from left at T-road intersection of Quarry Road (9500 W). TURN LEFT (north).
0.2	27.95	PARK as far off the pavement as you can safely along the east side of the road ACROSS from the office. CAUTION: heavy traffic. DO NOT BLOCK ACCESS to the quarry or its facilities. You MUST have permission and ***you must be at least 9 years old to enter this property!*** Strongly recommended: *wear a hard hat and safety glasses.*

STOP 5 At the Central Quarry, we'll examine the stone, discuss its importance to our quality of life, and collect some fossils (Office: SE NE SE SW Sec. 28, T35N, R7E, 3rd P.M., Kendall County; Lisbon 7.5-Minute Quadrangle [41088D4]).

Central Quarry produces stone from strata of Ordovician age, deposited as limey muds in shallow seas that covered this part of our present continent some 455 million years ago. We are near the southern limit of Ordovician exposures in northern Illinois. Just south of the quarry, Pennsylvanian rocks unconformably overlie the Ordovician strata. Strata of Silurian, Devonian, and Mississippian age are missing from this area. The time interval represented by these missing rocks is about 140 million years. Some beds in the quarry are quite fossiliferous.

The Illinois State Geological Survey completed its first detailed study of this quarry in 1956 and has returned several times for additional work. Following is a description of strata exposed in this quarry (modified from Willman and Kolata 1978):

Wisconsinan glacial till; 1 to 4 feet

ORDOVICIAN SYSTEM

Galena Group

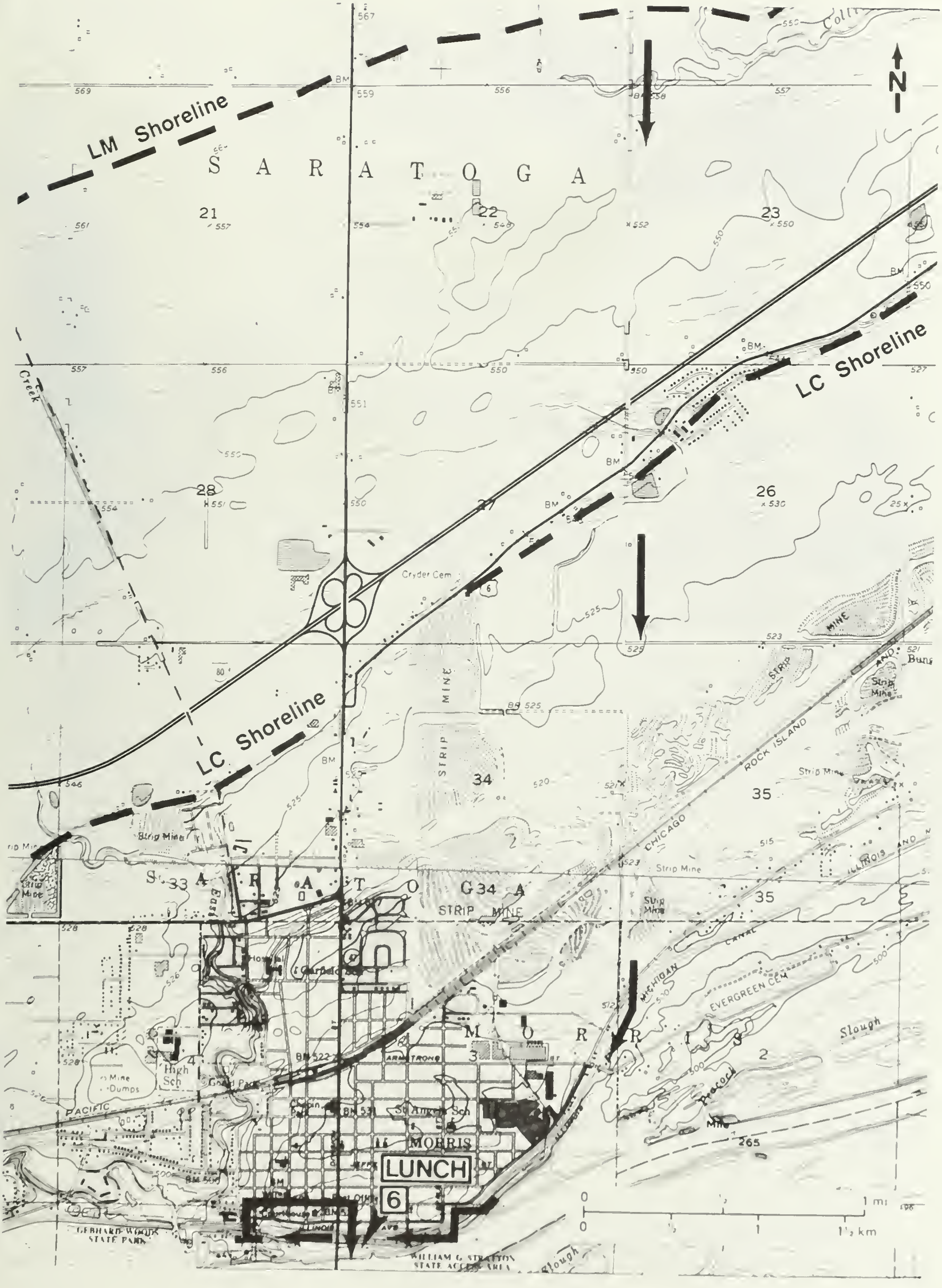
Dunleith Formation (may include Wise Lake Formation in upper part); 71 feet, 6 inches.

- Limestone—pure, light to medium gray, dolomite mottled, fossiliferous; fine grained with sand-size fossil debris; stylolites and large calcite-filled cavities near the top; 2 to 8 inch beds; several thin beds of *calcarenite*; 11 feet thick.
- Limestone—pure, light gray, dolomite mottled; 8" to 20" beds with very thin partings; crinoid fragments and molluscan fossils fairly common; several lenses of calcarenite, 3 to 18 inches thick; *stylolites* in some beds; 17.5 feet thick.

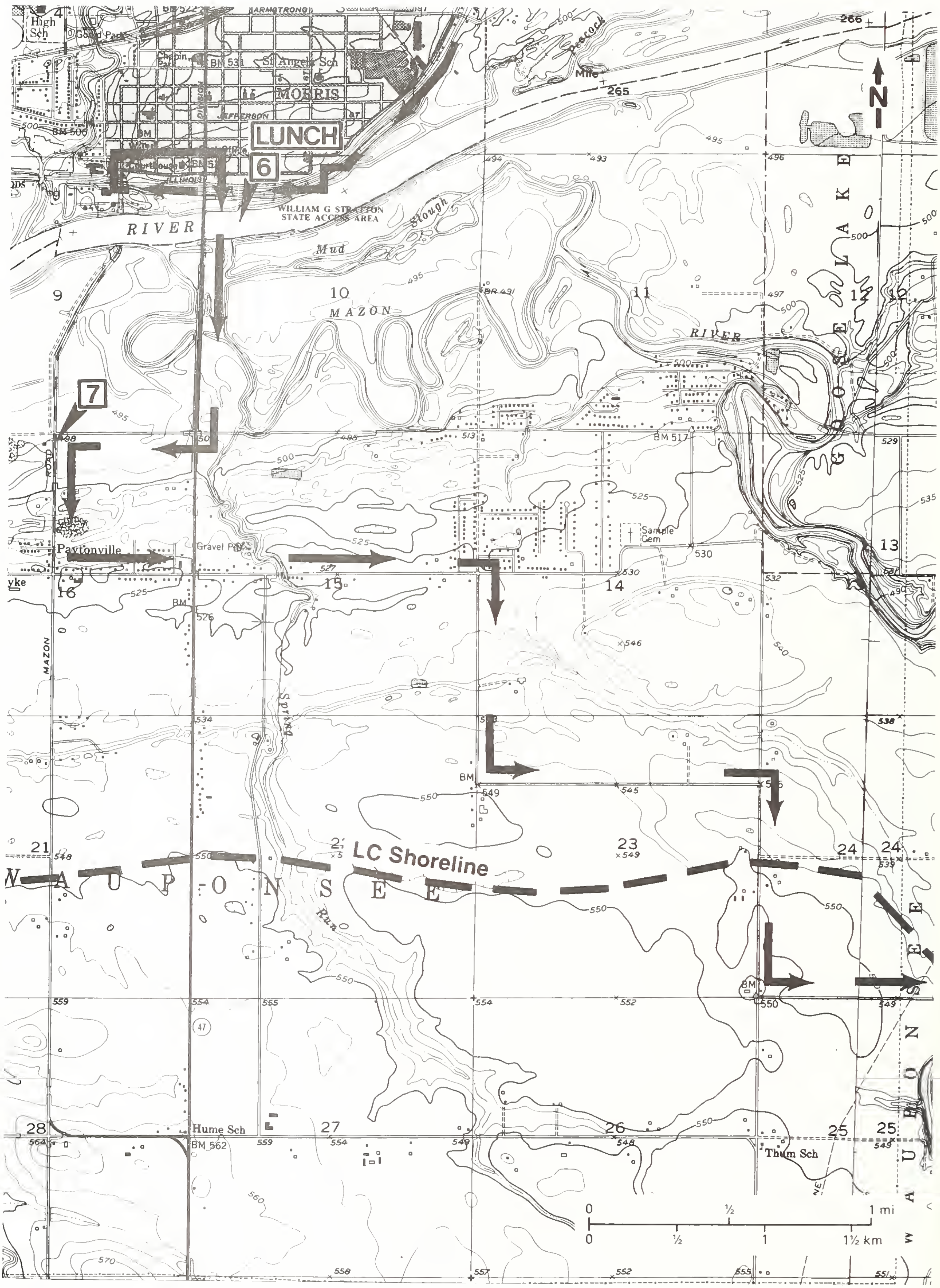
- Limestone—as above but slightly more *argillaceous*; 5 feet thick.
- Limestone—like the 17.5 foot unit above but more calcarenite beds and fewer fossils; prominent *ferruginous* corrosion surface 5 feet above base; 18 feet thick.
- Limestone—as above but 1 to 4 feet beds and more calcarenite; fossils abundant in some beds; 20+ feet thick.

The stone quarried and processed here is used for road materials, concrete, rip-rap, agricultural lime, construction, and miscellaneous products. A nearby quarry that produces quality stone is an asset to an area's economy. The cost of transporting high-bulk materials such as stone, however, can quickly outstrip the costs of producing the stone.

0.0	27.95	Leave stop 5. USE CAUTION in pulling back on the road. CONTINUE AHEAD (north).
0.3-	28.25-	STOP: 1-way at Joliet Road (16500 S). TURN RIGHT (east) to SR 47.
0.05-	28.25	STOP: 1-way at T-intersection on a curve with SR 47 (9500 W). CAUTION: FAST TRAFFIC. TURN RIGHT (southeast) on SR 47.
0.55+	28.8	Prepare to turn left onto White Willow Road.
0.1+	28.9+	TURN LEFT (east) onto White Willow Road (17000 S) from the SR 47 curve (9000 W). CAUTION: FAST TRAFFIC northbound.
1.0+	29.9+	TURN RIGHT (south) at crossroad on Ashley Road (8000 W).
0.1	30.0+	Pipeline crossing.
0.9	30.9+	STOP: 2-way at Sherrill (18000 S), the county line road between Kendall (north) and Grundy (south) Counties. CONTINUE AHEAD (south) with a slight jog to the left. In Grundy County, the intersection grid numbers change to Ashley (1000 E) and Sherrill (12000 N).
0.3	31.2+	We are back on the lake plain.
0.65+	31.9	STOP: 1-way at crossroad (11000 N). CONTINUE AHEAD (south) on Ashley Road.
1.1+	33.0+	Cross Valley Run.
0.6	33.6+	Cross glacial Lake Morris shoreline.
0.25+	33.85+	Cross Collins Run and then pipeline crossing.
1.15+	35.05	Cross I-80 overpass.
0.2+	35.25+	STOP: 2-way at crossroad, US 6 (7640 N). CONTINUE AHEAD (south) and drop down off glacial Lake Cryder shoreline just beyond US 6.
0.9	36.15+	The area to the left has been surface mined for coal. It is now being used for refuse disposal by EnviroTech. A short distance ahead, the area to the right has also been mined.
0.5	36.65+	CAUTION: Guarded single railroad track (the Chessie System, CSX).



LM Shoreline
LC Shoreline
LC Shoreline
SARATOGA
SARATOGA
MORRIS
N
LUNCH
6
Cryder Cem
STRIP MINE
ROCK ISLAND
CHICAGO
MICHIGAN
CANAL
EVERGREEN CEM
Slough
Peacock
High Sch
Mine Dumps
PACIFIC
GEBHARD WOODS STATE PARK
WILLIAM G. STRATTON STATE ACCESS AREA
0 1 mi
0 1 1½ km


LUNCH
6
7
MORRIS
WILLIAM G STRATTON STATE ACCESS AREA
RIVER
Mud Slough
MAZON RIVER
Paytonville
Gravel Pit
Sample Cem
GOOSE LAKE
LC Shoreline
WAUPONSEE
Spring Run
Hume Sch
Thum Sch
High Sch
Chapin Park
St Angela Sch
JEFFERSON
MAZON ROAD
0 ½ 1 mi
0 ½ 1 1½ km
N

0.5	37.15+	STOP: 2-way at slanted T-intersection. BEAR RIGHT (southwest) into Morris on Washington Street paralleling the I and M Canal behind the houses on the left side. CONTINUE AHEAD (southwest and west) on Washington Street across several side streets.
0.95+	38.15+	TURN LEFT (south) on Spruce Street.
0.05+	38.2+	TURN RIGHT (west) on Illinois Avenue.
0.1+	38.35	TURN LEFT (south) on Price Street.
0.05	38.4	CAUTION: Cross wooden bridge over the I and M Canal and enter the William B. Stratton State Access Area.
0.15+	38.55+	PARK where convenient in the lot.

STOP 6 LUNCH in William B. Stratton State Access Area on the Illinois Waterway (S/2 NW NW Sec. 10, T33N, R7E, 3rd P.M., Grundy County; Morris 7.5-Minute Quadrangle [41088C4]).

The Illinois River, flowing westward along the south edge of the William B. Stratton State Access Area, is only about 9 miles from its headwaters, the confluence of the Kankakee and Des Plaines Rivers. From its source to its mouth at the Mississippi River near Grafton, Illinois, the Illinois River is approximately 273 miles long, the longest segment of the Illinois Waterway. Here the river is 0.1 mile wide and its valley is little more than 1 mile wide.

The Illinois Waterway, which connects Lake Michigan to the Mississippi River Waterway via the Illinois River, the Chicago Sanitary and Ship Canal, and portions of the Des Plaines and Chicago Rivers, is 327 miles long. The waterway opened in 1933, providing a 9-foot minimum channel depth by means of seven locks and dams and intermittent dredging. In the 95 miles from Lake Michigan to Starved Rock, about 33 miles downstream to the west, five dams maintain nearly contiguous pools in which water levels drop a total of 135 feet. In the 231 miles below Starved Rock, two dams on the waterway drop the water level only 25 feet. The gradient (slope) of the river bottom through the lower segment is slightly less than 1.3 inches per mile, one of the lowest gradients of a major river. Despite its low gradient, the river does not meander and the waterway provides an exceptionally direct route from the Great Lakes to the Mississippi River Waterway. The Illinois Waterway is one of the nation's busiest inland waterways.

The upper Illinois Valley has been an area of intensive industrial development for many years, partly because of its closeness to relatively inexpensive water transporation. The use of the waterway has increased markedly as a result. Enlargement of the waterway's capacity to handle the increasing demands placed upon it has been underway for several years. Because of the demands and stresses on the environment and the mineral resources of the land near the waterway, the ISGS studied and published a report (Willman 1973) on the earth materials directly underlying the ground surface along a strip 1 to 3 miles wide on either side of the waterway. The report focuses on solving present problems and planning effectively for the future.

0.0	38.55+	Leave Stop 6 and CONTINUE AHEAD (west) out of the parking lot.
0.05	38.6+	STOP: 1-way. CONTINUE AHEAD (west) along the south side of the canal.
0.05+	38.7	We are passing under the SR 47 bridge.
0.3	39.0	STOP: 2-way at Calhoun Street. CAUTION: heavy truck traffic to loading facilities. TURN RIGHT (north) and cross the I and M Canal.

0.05+	39.05+	TURN RIGHT (east) on Illinois Avenue.
0.3	39.35+	STOP: 2-way at intersection with Division Street and SR 47. CAUTION: heavy traffic. TURN RIGHT (south) on SR 47.
0.05-	39.4	CAUTION: cross the I & M Canal bridge and then the narrow 2-lane Illinois River bridge.
0.85+	40.25+	STOP LIGHT: TURN RIGHT (west) on Pine Bluff Road (4000 N).
0.45+	40.75+	STOP: 4-way at Dwight (Mazon) Road (8500 W). CAUTION: heavy truck traffic crosses the intersection traveling to and from the sand and gravel pit. TURN LEFT (south).
0.05-	40.8	PARK along the roadway as far off the road as you can safely. Do NOT block any gates or roadways. You MUST HAVE permission to enter this property. Enter ONLY through the gate.

STOP 7 We will view a large sand and gravel pit of Materials Service Corporation from the shop area (Entrance gate: NE_{cor} NW Sec. 16, T33N, R7E, 3rd P.M., Grundy County; Morris 7.5-Minute Quadrangle [41088C4]).

In 1919, Henry, Sol, and Irving Crown established the Material Service Corporation as a sand and gravel company on Chicago's north side. The corporation entered the ready-mix concrete business in 1949 after it had acquired an aggregate producing operation. In 1958, Material Service merged with General Dynamics Corporation, a major defense contractor.

Material Service opened Morris No. 1 sand pit as a dredge operation in 1947. Sand produced here is carried by company-owned barges on the Illinois Waterway to Material Service or customer yards located along the Chicago Sanitary and Ship Canal. A channel was dredged in 1955 from the Illinois River south to the pit. This channel is now about 0.6 mile long and several hundred feet wide to accommodate barges and towboats. In 1956, Material Service purchased a dredge, the cutting head of which is at the end of a 48-foot long ladder. The dredge enables the company to cut and lift materials from about 25 feet below water level. The pit extends south-southwest for about 2.5 miles and is about 0.25 mile at its widest.

Surface materials here are the Cahokia Alluvium of Holocene age. The Cahokia Alluvium is generally 2 to 3 feet thick, but occasionally it is slightly thicker. Beneath this thin cover, the underlying sand, sandy gravel, and gravel belong to the Wisonsinan Henry Formation. Here the deposit is 25 to 50 feet thick, but it infrequently thins to about 10 feet. Gravel is reduced to sand size in the firm's floating crusher plant.

Economical water transportation of this high-bulk mineral resource is possible using the company's marine fleet, which consists of 6 towboats and 93 barges. The barge capacity is from 1,100 to 1,600 tons.

0.0	40.8	Leave Stop 7 and CONTINUE AHEAD (south).
0.45+	41.25+	STOP: 4-way at crossroad. TURN LEFT (east) on Southmor Road (3500 N).
0.5	41.75+	STOP: 2-way at SR 47. CAUTION: heavy traffic. CONTINUE AHEAD (east) on Southmor Road. We are travelling along a glacial sluiceway.
0.3	42.05	Cross Spring Run.
0.65+	42.75+	STOP: 4-way at School Drive (1000 E). TURN RIGHT (south).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8

0.35+	43.1+	The small rise in the road is the south side of the glacial sluiceway that we have been travelling across.
0.35+	43.5	TURN LEFT (east) on Southard Road (2750 N).
1.0	44.5	STOP: 1-way at Higgins Road (2000 E). TURN RIGHT (south).
0.25-	44.7-	Cross glacial Lake Cryder shoreline.
0.5	45.25	TURN LEFT (east) at T-intersection onto North Oxbull Road (2800 N).
1.15+	46.4+	TURN RIGHT (south) on White Tie Road (3000 E) and immediately cross Mazon River. Notice the rock outcrops up the river (right) and boulder erratics downstream (left).
1.15	47.55+	Mazon River on the left side. Notice the great amount of rock that has been pushed over the side in an attempt to control erosion.
0.1	47.65+	T-road from right: Norman Road. CONTINUE AHEAD (east).
0.25	47.9+	PARK along the narrow roadside as far off the road as you can safely. CAUTION: watch for traffic. Stay away from the edge—it's very dangerous. Watch where you put your feet.

STOP 8 From this vantage point along Mazon River, we can view the strata that overlie the Colchester (No.2) Coal Member (N side of road SE_{cor} SW NW Sec. 29, T33N, R8E, 3rd P.M., Grundy County; Coal City 7.5-Minute Quadrangle [41088C3]).

Mazon River has eroded its channel into the Francis Creek Shale Member of the Pennsylvanian Carbondale Formation (fig. 9 and appendix, *Depositional History of the Pennsylvanian Rocks in Illinois*). In this part of northeastern Illinois, the shale may be 80 feet thick locally and the lower part is light gray and silty, with occasional lenticular sandstone lenses. The sandstone down the slope here at the top of the bedrock section may be one of these lenses, or perhaps, it is a channel sandstone that was deposited in an ancient stream valley of Pennsylvanian age. The sandstone, which is blocky and thick-bedded, is a protective cap above the softer, weaker shale. The sandstone also conducts water from the overlying glacial deposits to the river bank, a process that helps to slow down slumping of these softer materials. The coarseness of the shale and sandstone indicates that a source area for them must have been fairly close to the northeast from here. The Francis Creek becomes finer grained toward the southwest, indicating greater distance from the source area.

The severe slumping that occurs along the north side of the road in this vicinity is due to several factors: the Mazon River has undercut the base of the steep slope; the slope is too steep and unstable; and frequent rains, especially during late winter and spring, saturate the upper glacial deposits and soil. No direct sunlight helps dry out the exposure. Water percolates down through these soft earth materials until it reaches the shallow shale or sandstone bedrock. As noted above, the generally porous and permeable sandstone conducts water to seeps and springs along the bank. When water encounters shale, it also moves along the interface or contact between the materials toward the bank. When the shale gets wet, however, it becomes slippery and the overlying weak glacial materials readily slough off it at the bank.

Rock, concrete, broken pavement, and refuse are frequently dumped down the slope to cover and "protect" the materials from slumping. These "protective" materials generally are more harmful because they add more weight to an already unstable situation and cause additional slumping. Further slumping could be prevented or minimized by protecting the toe or base of the slope from further direct attack by the river, and then dewatering the overlying glacial material.

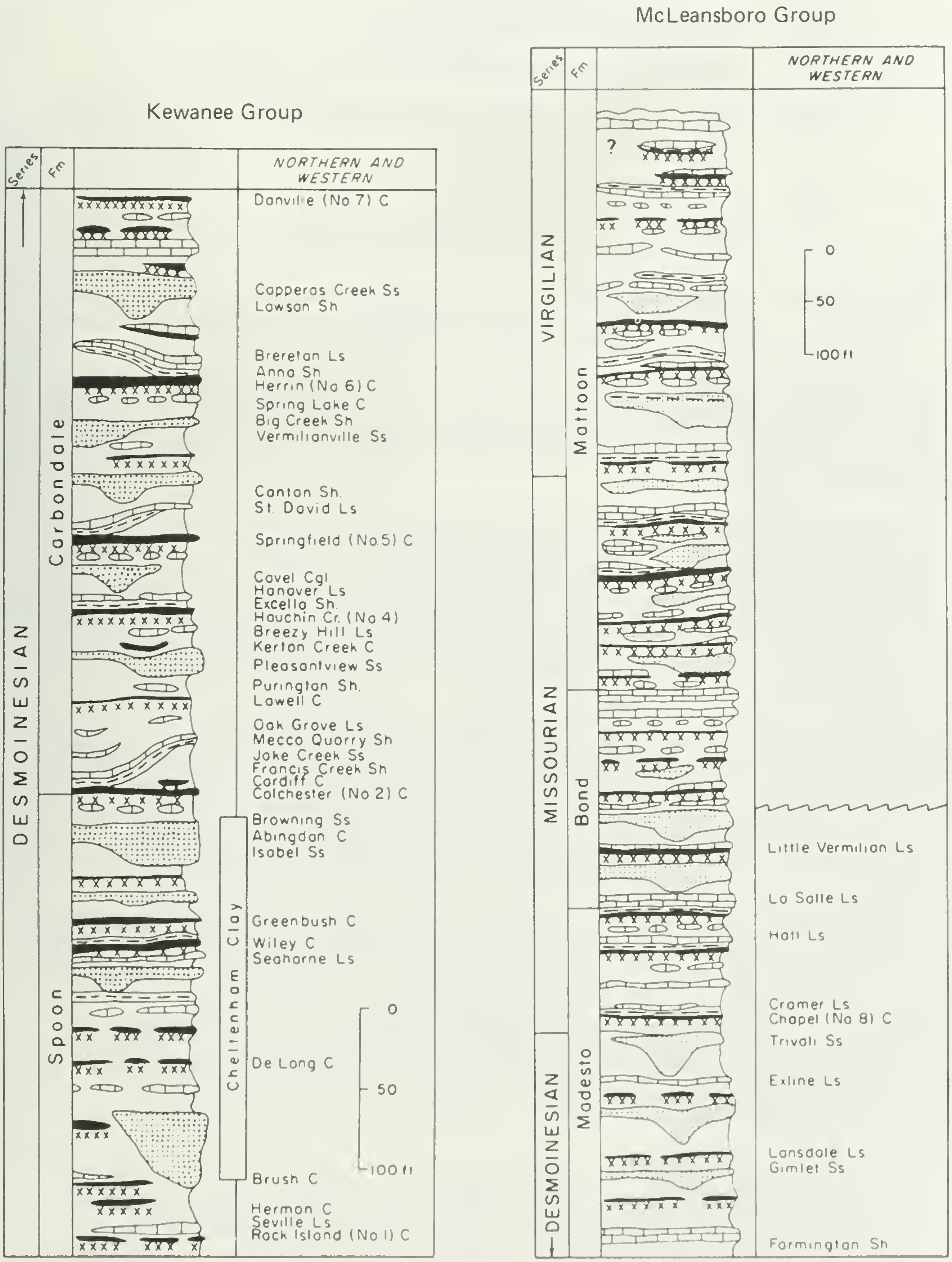

Figure 9 Generalized geologic column of the strata in the Kewanee and McLeansboro Group in northern and western Illinois. (Not all units are present in the field trip area.)

0.0	47.9+	Leave Stop 8. CONTINUE AHEAD (east).
0.5	48.4+	The body of water to the left (north) is a surface mine pond.
0.25+	48.65+	STOP: 2-way at crossroad of Jugtown Road (5000 E) and White Tie Road (1500 N). TURN LEFT (north).
0.25+	48.99+	Pipeline crossing.
2.25+	51.2+	STOP: 2-way at crossroad of Pine Bluff Road (4100 N). CONTINUE AHEAD (north) towards Goose Lake Prairie State Natural Area.
1.05+	52.25+	STOP: 3-way. TURN RIGHT (east) at the entrance to Goose Lake Prairie State Natural Area and proceed to the nature center parking area. Mileage figures will resume from this intersection.

STOP 9 We will discuss the Kankakee Flood from our vantage point at the south end of the Gunnar A. Peterson Visitor Center parking lot, Goose Lake Prairie State Natural Area (NE SW SE SW Sec. 4, T33N, R8E, 3rd P.M., Grundy County; Coal City 7.5-Minute Quadrangle [41088C3]).

This relatively low-lying area is part of the glacial sluiceway created when the ice front rapidly melted back into the Lake Michigan Basin some 16,500 years B.P. Glaciers from the Saginaw and Erie Lobes in Michigan and Indiana coalesced with the Lake Michigan Lobe in such a way that meltwater drained westward into the lowland between the Lake Michigan ice front and the moraines south of it. Water finally spilled over a sag in the moraine to the south and drainage was established to the south and west down what is now the Kankakee River Valley. This huge amount of meltwater is known as the Kankakee Flood. Some earlier geologists called it the Kankakee Torrent.

The torrent of meltwater pouring down the Kankakee Valley was fast enough to rip up and carry slabs of Silurian dolomite up to 2 feet in diameter. The rushing water scoured the glacial till, removing most of it except for boulders, which may not have been moved very far. Long bars of rubble accumulated behind many boulders and rock knobs. The coarseness of these deposits decreases downstream, indicating that the volume and velocity of the water became progressively lower. The stream could no longer transport the larger materials and they were left behind.

Not all of this meltwater was able to flow from the area via the outlet in the Marseilles Moraine from Seneca to Ottawa, and a large lake, the Wauponsee, formed behind the Ransom Moraine in the Morris Basin. Downcutting of the outlet was not rapid enough to keep pace with rising water levels; therefore, the water eventually reached a sag in the moraine on the south and drained into areas behind more distant moraines to form Lake Watseka, Lake Pontiac, and Lake Ottawa. The process that formed the three lakes probably lasted for only a few years. The flood waters quickly slowed when they flowed into these rapidly rising lakes, and the finer materials, such as clay, silt, and fine sand, were deposited in the more quiet lake waters away from the main stream flows.

The outlet through the Marseilles Moraine where Seneca now lies was eventually downcut and the lake level began to lower. As the lobes continued to melt, another outlet to the east was finally opened southward along the Wabash Valley and much of the meltwater from the Erie Lobe was diverted from the Kankakee Valley. The flood continued to diminish and the water flowed through several channels, giving the appearance of a *braided stream*. Eventually, the meltwater became confined to the present Kankakee and Illinois Rivers.


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Mine Dump
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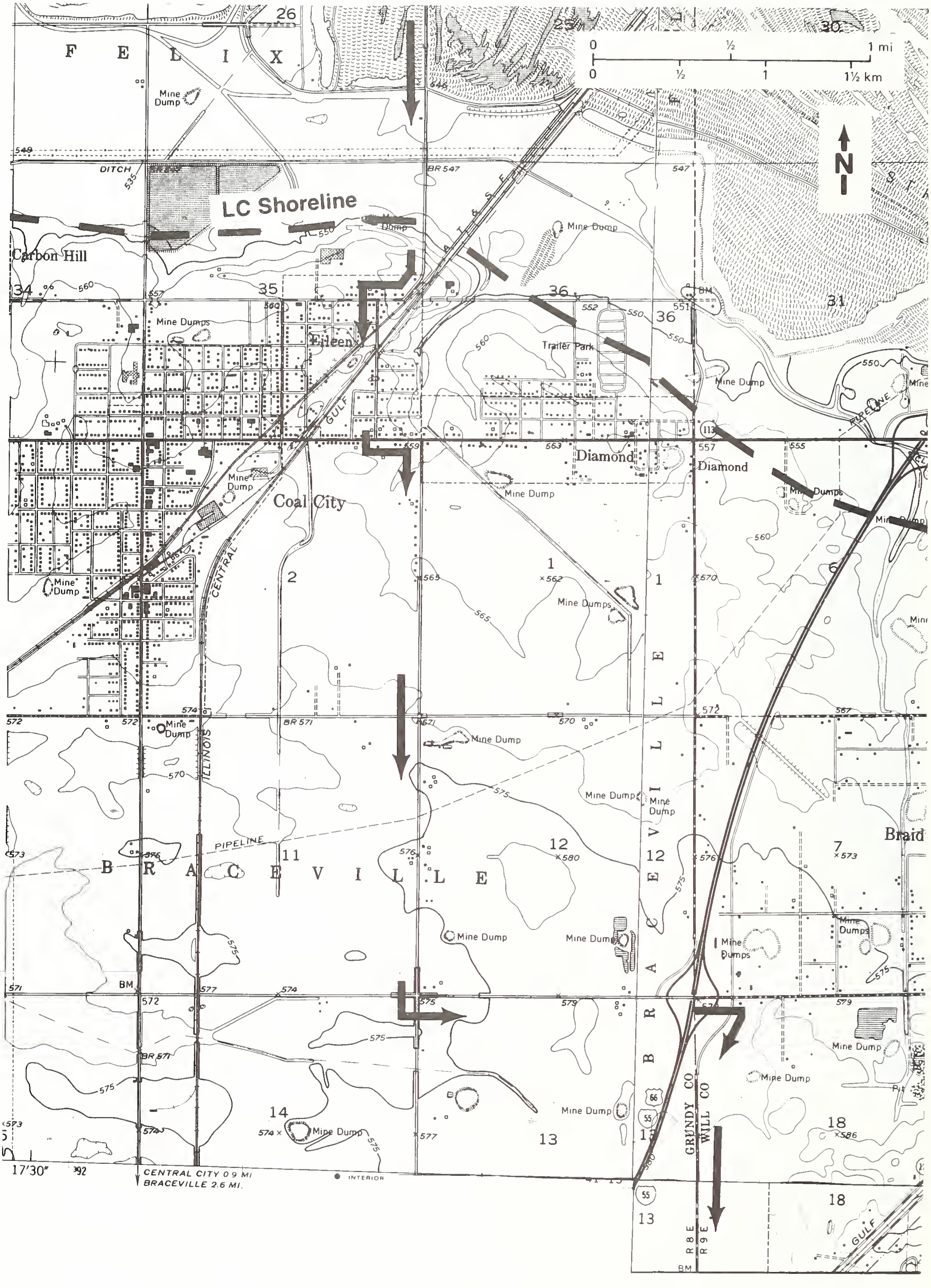

FELIX
LC Shoreline
Carbon Hill
Eileen
Coal City
Diamond
Trailer Park
Mine Dump
Mine Dumps
BRACEVILLE
BRACEVILLE
Braid
GRUNDY CO
WILL CO
ILLINOIS CENTRAL
GULF
PIPELINE
DITCH
R 8 E
R 9 E
CENTRAL CITY 0.9 MI
BRACEVILLE 2.6 MI.
17'30"
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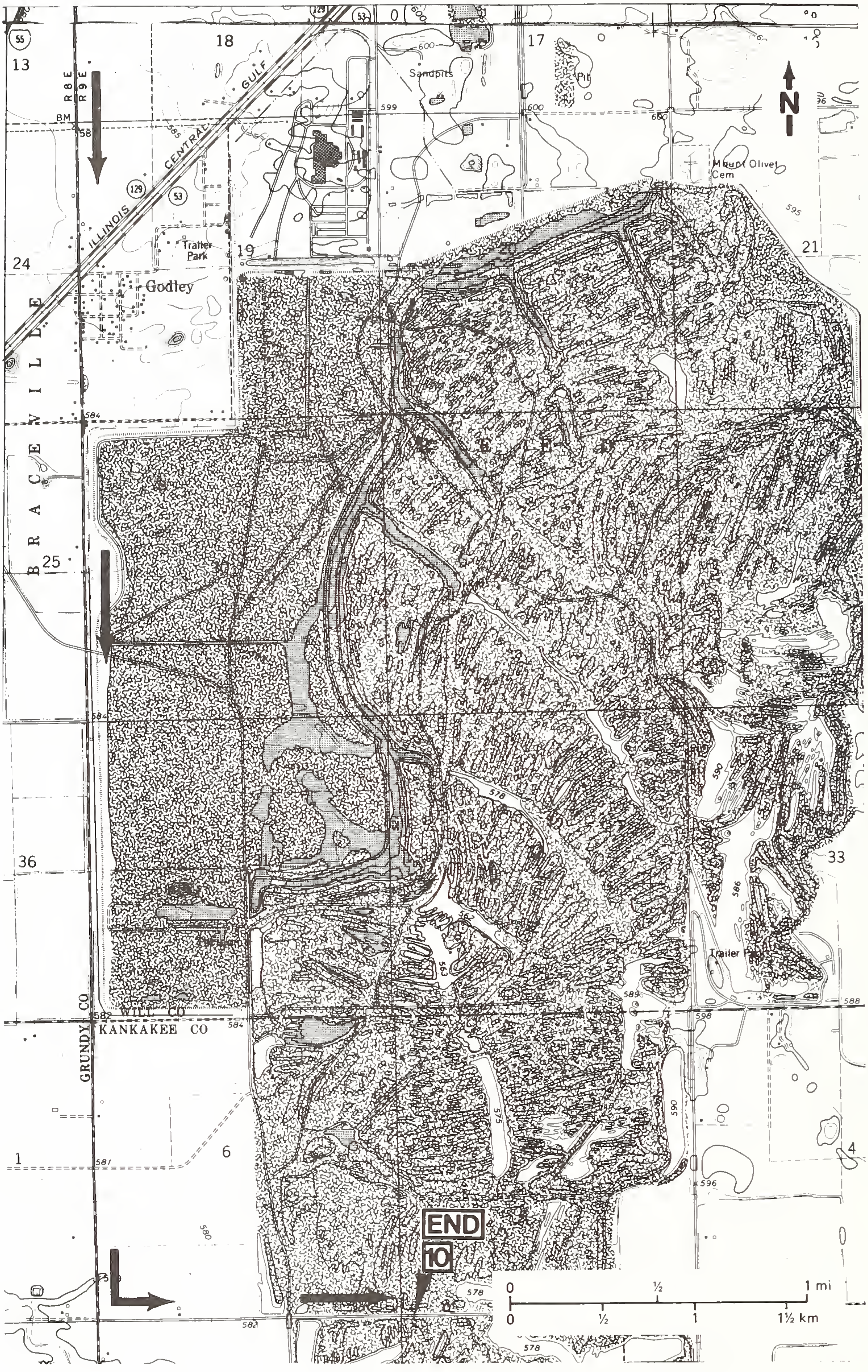
N

In the immediate area, there appears to be a considerable amount of scour by floodwaters, which left channels across the area and concentrations of boulders along their sides. As lake levels rose later, silts and muds settled out of the floodwaters to thinly bury the boulders. Because of farming practices, erosion, and frost heave, the boulders have come closer to the surface and are struck sometimes by plows. You will notice that farmers have piled cobbles and boulders along the sides of field. Some of the low surface sags are marshy tracts in which organic deposits of peat and muck are accumulating.

A short distance to the east is an area that was surface mined for clay that occurs in the Pennsylvanian Spoon Formation (Stop 8/fig. 9). This locally thick, good refractory clay that underlies the Colchester Coal is probably equivalent to the famous Cheltenham Clay of the St. Louis area. Part of the mined-out area has been reclaimed and incorporated into this natural area.

0.0	52.25+	Leave Stop 9. TURN LEFT (south) at the entrance gate.
1.05+	53.3+	STOP: 2-way at Pine Bluff Road (4100 N). TURN LEFT (east).
2.95+	56.3	STOP: 4-way at Dresden Road. TURN RIGHT (south) and ascend the erosional scarp of a glacial sluiceway.
0.85+	57.15+	The barn to the right was built on a dune of Wisconsinan Parkland Sand. Some of these dunes have been stabilized with forest cover.
0.5	57.65+	The very old surface-mine spoil piles to the right have a dense overgrowth.
1.6	59.25	CAUTION: narrow bridge across Claypool Ditch that flows across a glacial lake plain.
0.2+	59.5	Cross glacial Lake Cryder shoreline and area of Parkland Sand to the south of it.
0.15+	59.65+	BEAR RIGHT (southwest and then west) and enter town of Eileen on North Street.
0.2	59.85+	TURN LEFT (south) at T-intersection of North 5th Avenue.
0.1	60.0-	CAUTION: 2-track guarded Atchison, Topeka, and Santa Fe (AT&SF) railroad crossing. Fast trains!
0.05+	60.05+	CAUTION: guarded 3-track railroad crossing, Southern Pacific (SP)/Amtrak.
0.15	60.2+	STOP: 4-way. CONTINUE AHEAD (south).
0.15+	60.35+	STOP: 1-way at T-intersection with East Division Street/SR 113. TURN LEFT (east).
0.15+	60.55	TURN RIGHT (south) at T-intersection onto Berta Road just west of the bank.
0.55	61.1+	The mine refuse (gob) pile, nearly 0.75 mile to the left (east), is the shaft site of the Wilmington Coal Mining and Manufacturing Company's Diamond Mine. Disaster struck this mine on February 16, 1883, when excess surface water from rainfall and an early thaw broke through into the underground workings, drowning 69 men and boys. The main shaft was only 84 feet deep; the Colchester Coal averaged 3 feet thick.


END
10
Godley
Trailer Park
Sandpits
Pit
Mount Olivet Cem
Trailer Park
ILLINOIS CENTRAL GULF
BRACEVILLE
GRUNDY CO
WILL CO
KANKAKEE CO
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0.05	61.15+	To the upper left at about 10:30 o'clock is Commonwealth Edison's Braidwood Nuclear Power Station.
0.35+	61.5+	CAUTION: crossroad. CONTINUE AHEAD (south).
0.95+	62.5+	STOP: 2-way at crossroad. TURN LEFT (east).
0.9	63.4+	I-55 interchange. CONTINUE AHEAD (east).
0.1	63.5+	Cross I-55 and prepare to turn right on the east side frontage road.
0.1	63.65+	TURN RIGHT (south) on the frontage road.
0.25+	63.9+	Curve left (south) onto the Will-Grundy County Line Road.
1.25	65.15+	STOP: 2-way at SR 129. CAUTION: fast traffic. CONTINUE AHEAD (south) and cross single guarded Illinois Central (IC) railroad crossing.
0.05	65.2+	STOP: 2-way intersection at SR 53. CONTINUE AHEAD (south) on Kankakee Street in the hamlet of Godley.
0.2	65.4	STOP: 3-way at Livingston Street T-intersection. CONTINUE AHEAD south on Kankakee Street for several miles.
0.4	65.8	The large berm on the left is the dike around the cooling lake for the Braidwood Nuclear Power Station.
0.6	66.4	Cross a low dune of Parkland Sand.
1.25	67.65	To the left (east) at the crossroads at south end of cooling lake is Will-Kankakee County Line. Kankakee County is to the south. CONTINUE AHEAD (south).
0.45+	68.1+	Crossroads. CONTINUE AHEAD (south).
0.5+	68.6+	Crossroad. TURN LEFT (east) on (5000 N). CAUTION: rough road.
0.55+	69.2+	The garage for servicing the large off-highway pit trucks of the abandoned Northern Illinois Mine of Peabody Coal Company was located just to the south of this ditch on the right. CONTINUE AHEAD (east).
0.45+	69.7	PARK along the roadway. You MUST HAVE permission to enter these properties even though there are no fences (Commonwealth Edison Electric Company, Illinois Department of Conservation, and the South Wilmington Sportsmen's Club).

STOP 10 We will have the opportunity to collect plant and animal fossils from the spoil piles In Commonwealth Edison Pit 11 (formerly Peabody Coal Company, Northern Illinois Mine, Pit 11) (Ctr S line SW SW SW Sec. 5, T31N, R9E, 3rd P.M., Kankakee County; Essex 7.5-Minute Quadrangle [41088B2]).

In 1928, large-scale surface mining began in northern Illinois in the Colchester (No. 2) Coal Member, the lowermost member of the Pennsylvanian Carbondale Formation (Stop 8/fig. 9; appendix, *Depositional History of the Pennsylvanian Rocks in Illinois*). The first surface mines were confined to areas of thin overburden near the outcrop of the coal seam. As mining equipment became more sophisticated, however, mine operators were able to recover the relatively thin coal from greater depths.

In this vicinity, the Colchester Coal averaged about 3 feet thick, whereas in most other parts of Illinois it was 24 to 30 inches thick. As noted previously, the Colchester Coal is overlain by the Francis Creek Shale, which is about 35 feet thick in this area. The latter is unconformably overlain by Wisconsinan Wedron Formation till and Parkland Sand.

Plant fossils are often found in the Francis Creek Shale exposed in Pit 11, but marine invertebrate fossils are more common. The Wilmington-Coal City-Braidwood area of northeastern Illinois is famous for an array of well-preserved flora and fauna. A number of books and scientific articles describe and illustrate the paleobotany/paleontology of the area. The fossils are preserved in siderite ($FeCO_3$—iron carbonate) concretions or nodules that range from less than 1 inch in diameter to more than 1 foot long and several inches wide. Not all concretions from this area are fossiliferous, however. The fossil plates in the attached *Depositional History of the Pennsylvanian Rocks In Illinois* will help you identify many of the specimens that you collect.

To find out whether you have specimens in the concretions that you have collected, you will need to open them up. WEAR SAFETY GLASSES OR GOGGLES when working on the specimens. Place the concretion on a solid base, such as a large rock, and orient it so that you hold the short axis between your thumb and forefinger. Then, GENTLY TAP it around its entire circumference as you slowly rotate it about its short axis. WATCH YOUR FINGERS as you tap the specimen. You will NOT always get a clean break that will expose the whole specimen, especially if you strike it too hard and do not rotate it enough. Several rotations with LIGHT tapping are better than sharp blows with only one or two rotations.

Tom Testa, a local authority, gets the best results by covering the concretions with water in a plastic pail. You then subject the concretions to a series of freeze-thaw cycles until they break open either of their own accord or with very gentle taps. If they don't open readily, subject them to further freeze-thaw cycles. Remember, not all concretions contain specimens! If you don't have a large freezer at home to perform these cycles, you'll have to wait until winter for nature's help.

END OF FIELD TRIP.

TO LEAVE THIS LOCALITY:

Continue straight ahead for 0.9 mile: then (A) turn right (south) for 0.25 mile, then left (east) for 1.0 mile to Essex-Braidwood Road; left (north) to SR 113 and Braidwood or right (south) to Essex, <u>or</u> (B) turn right (south) for 1.0 mile to the Essex-South Wilminton Road; then left to Essex or right (west) to South Wilmington and Gardner (I-55).

Backtrack for 1.05 mile: then (A) south 1 mile to Essex-South Wilmington Road; the latter is to the right (west) and then to Gardner (I-55 South), <u>or</u> (B) north through Godley to I-55 North interchange.

HAVE A SAFE JOURNEY HOME.

BIBLIOGRAPHY

Berg, R. C., J. P. Kempton, L. R. Follmer, D. P. McKenna, R. J. Krumm, J. M. Masters, R. C. Anderson, R. L. Meyers, J. E. King, H. E. Canfield, and D. M. Mickelson, contributors, 1985, Illinoian and Wisconsinan Stratigraphy and Environments in Northern Illinois: the Altonian Revised: 32nd Field Conference of the Midwest Friends of the Pleistocene, Illinois State Geological Survey, Guidebook 19, 177 p.

Clegg, K. E., 1965, The La Salle Anticlinal Belt and adjacent structures in east-central Illinois: Transactions of the Illinois State Academy of Science, v. 58, no. 2, p. 82-94.

Culver, H. E., 1922, Geology and Mineral Resources of the Morris Quadrangle: Illinois State Geological Survey, Bulletin 43 extract, 114 p.

Damberger, H. H., 1991, Coalification in North American coal fields, *in* H. J. Gluskoter, D. D. Rice, and R. B. Taylor, eds., Economic Geology (U.S), The Geology of North America, Geological Society of America, Boulder, Colorado, v. P-2, p. 503-522.

Emrich, G. H., and R. E. Bergstrom, 1962, The Des Plaines Disturbance, northeastern Illinois: Geological Society of America, Bulletin, v. 73, p. 959-968.

Horberg, C. L., 1950, Bedrock Topography of Illinois: Illinois State Geological Survey, Bulletin 73, 111 p.

Illinois Department of Conservation, ca. 1985, Illinois and Michigan Canal State Trail, Gebhard Woods, park map, 2 p.

Illinois Department of Conservation, 1990, Goose Lake Prairie State Natural Area, brochure, 12 p.

Illinois Department of Conservation, ca. 1990, Illinois and Michigan Canal State Trail, brochure, 16 p.

Killey, M. M., 1982, The Dwight Mineralogical Zone of the Yorkville Till Member, Northeastern Illinois: Illinois State Geological Survey, Circular 526, 25 p.

Leighton, M. M., G. E. Ekblaw, and C. L. Horberg, 1948, Physiographic Divisions of Illinois: Illinois State Geological Survey, Report of Investigations 129, 19 p.

Lineback, J. A., and others, 1979, Quaternary Deposits of Illinois: Illinois State Geological Survey map, scale 1:500,000, size 40×60 inches, color.

National Association of State Land Reclamationists, 1988, Tour booklet: Material Service Corporation, 13 p.

Odom, I. E., G. M. Wilson, G. Dow, E. Cording, and P. Dohm, 1961, Morris Area: Illinois State Geological Survey, Geological Science Field Trip Guide Leaflet 1961C, 13 p.

Piskin, K., and R. E. Bergstrom, 1975, Glacial Drift in Illinois: Illinois State Geological Survey, Circular 490, 35 p.

Reinertsen, D. L., 1984, Guide to the Geology of the Morris Area: Illinois State Geological Survey, Educational Extension Guidebook 1984B, 16 p.

Reinertsen, D. L., and M. M. Killey, 1972, Guide to the Geology of the La Salle Area: Illinois State Geological Survey, Educational Extension Guidebook 1971D, 28 p.

Samson, I. E., (in press), Illinois Mineral Industry in 1990 and Review of Preliminary Mineral Production Data for 1991: Illinois State Geological Survey, Illinois Minerals.

Treworgy, J. D., 1981, Structural Features in Illinois: A Compendium: Illinois State Geological Survey, Circular 519, 22 p.

Will County Forest Preserve District, Cook County Forest Preserve District, and Illinois Department of Conservation, 1992, The I & M Canal National Heritage Corridor-Canoe Guide, brochure, 16 p.

Willman, H. B., 1973, Geology Along the Illinois Waterway-A Basis for Environmental Planning: Illinois State Geological Survey, Circular 478, 48 p.

Willman, H. B., and J. C. Frye, 1970, Pleistocene Stratigraphy of Illinois: Illinois State Geological Survey, Bulletin 94, 204 p.

Willman, H. B., and others, 1967, Geologic Map of Illinois: Illinois State Geological Survey, scale 1:500,000; size 40×56 inches, color.

Willman, H. B., J. A. Simon, B. M. Lynch, and V. A. Langenheim, 1968, Bibliography and Index of Illinois Geology through 1965: Illinois State Geological Survey, Bulletin 92, 373 p.

Willman, H. B., E. Atherton, T. C. Buschbach, C. W. Collinson, J. C. Frye, M. E. Hopkins, J. A. Lineback, and J. A. Simon, 1975, Handbook of Illinois Stratigraphy: Illinois State Geological Survey, Bulletin 95, 261 p.

GLOSSARY

Several sources were used for the definitions, but the main reference is the *Glossary of Geology*, edited by Robert L. Bates and Julie A. Jackson (American Geological Institute, 1987).

Age — An interval of geologic time; a division of an epoch.

Alluviated valley — One that has been at least partly filled with sand, silt, and mud by flowing water.

Alluvium — A general term for clay, silt, sand, gravel, or similar unconsolidated detrital material deposited during comparatively recent time by a stream or other body of running water as a sorted or semisorted sediment in the bed of a stream or on its floodplain or delta.

Anticline — A convex upward rock fold in which strata have been bent into an arch; the strata on each side of the core of the arch are inclined in opposite directions away from the axis or crest; the core contains rocks older than those on the perimeter of the structure.

Aquifer — A geologic formation that is water-bearing and transmits water from one point to another.

Argillaceous — Largely composed of clay-sized particles or clay minerals.

Bed — A naturally occurring layer of earth material of relatively greater horizontal than vertical extent; it is characterized by a change in physical properties from overlying and underlying materials. It also is the ground upon which any body of water rests or has rested; the land covered by the waters of a stream, lake, or ocean; or the bottom of a watercourse or stream channel.

Bedrock — The solid rock underlying the unconsolidated (non-indurated) surface materials such as soil, sand, gravel, and glacial till.

Bedrock valley — A drainageway eroded into the solid bedrock beneath the surface materials. It may be completely filled with unconsolidated (non-indurated) materials and hidden from view.

Braided stream — A low gradient, low volume stream flowing through an intricate network of interlacing shallow channels that repeatedly merge and divide, and are separated from each other by branch islands or channel bars. Such a stream may be incapable of carrying all of its load.

Calcarenite — Limestone composed of sand-sized grains consisting of more or less worn shell fragments or pieces of older limestone; a clastic limestone.

Calcareous — Containing calcium carbonate ($CaCO_3$); limy.

Calcite — A common rock-forming mineral consisting of $CaCO_3$; it may be white, colorless, or pale shades of gray, yellow, and blue; it has perfect rhombohedral cleavage, appears vitreous, and has a hardness of 3 on the Mohs' scale; it effervesces (fizzes) readily in cold dilute hydrochloric acid. It is the principal constituent of limestone.

Chert — Silicon dioxide (SiO_2); a compact, massive rock composed of minute particles of quartz and/or chalcedony; it is similar to flint but lighter in color.

Clastic — Fragmental rock composed of detritus, including broken organic hard parts as well as rock substances of any sort.

Concretion — A hard, compact, commonly rounded (but also disk-shaped or irregular in form) mass or aggregate of mineral matter; usually of a composition widely different from that of the rock in which it is found.

Crystalline — Said of a rock consisting wholly of crystals or fragments of crystals; esp. said of an igneous rock developed through cooling from a molten state and containing no glass, or of a metamorphic rock that has undergone recrystallization.

Delta — A low, nearly flat, alluvial land deposited at or near the mouth of a river where it enters a body of standing water; commonly a triangular or fan-shaped plain sometimes extending beyond the general trend of the coastline.

Detritus — Material produced by mechanical disintegration.

Diamictite — A comprehensive, nongenetic term...for a nonsorted or poorly sorted, noncalcareous, terrigenous sedimentary rock that contains a wide range of particle sizes, such as a rock with sand and/or larger particles in a muddy matrix; e.g. a tillite or a pebbly mudstone.

Diamicton — A general term...for the nonlithified equivalent of a diamictite; e.g. a till.

Disconformity — An *unconformity* marked by a distinct erosion-produced, irregular, uneven surface of appreciable relief between parallel strata below and above the break; sometimes represents a considerable interval of nondeposition.

Dolomite — A mineral, calcium-magnesium carbonate ($CaMg(CO_3)_2$; applied to those sedimentary rocks that are composed largely of the mineral dolomite; it is also precipitated directly from seawater. It is white, colorless, or tinged yellow, brown, pink, or gray, and has perfect rhombohedral cleavage; it appears pearly to vitreous, and effervesces feebly in cold dilute hydrochloric acid.

Drift — All rock material transported by a glacier and deposited either directly by the ice or reworked and deposited by meltwater streams and/or the wind.

End moraine — A ridge-like or series of ridge-like accumulations of drift that develop along the margin of an actively flowing glacier at any given time; a moraine that has been deposited at the lower or outer end of a glacier.

Eon — The largest division of geologic time; it consists of two or more eras.

Epoch — An interval of geologic time; a division of a period.

Era — A unit of geologic time that is next in magnitude beneath an eon; consists of two or more periods.

Fault — A fracture surface or zone in earth materials along which there has been vertical and/or horizontal displacement or movement of the strata on both sides relative to one another.

Ferruginous — Pertaining to or containing iron, e.g., a sandstone that is cemented with iron oxide.

Floodplain — The surface or strip of relatively smooth land that lies adjacent to a stream channel and has been produced by stream erosion and deposition; the area covered with water when the stream overflows its banks at times of high water; it is built of alluvium carried by the stream during floods and deposited in the sluggish water beyond the influence of the swiftest current.

Fluvial — Of or pertaining to a river or rivers.

Fluviolacustrine — Pertains to sedimentation partly in lake water and partly in streams, or to sediments deposited under alternating or overlapping lacustrine and fluvial conditions.

Formation — The basic rock unit distinctive enough to be readily recognizable in the field and widespread and thick enough to be plotted on a map. It describes the strata, such as limestone, sandstone, shale, or combinations of these and other rock types; formations have formal names, such as Joliet Formation or St. Louis Limestone (Formation), which are usually derived from geographic localities.

Geologic column — a chart that shows the subdivisions of part or all of geologic time or the sequence of stratigraphic units (oldest at the bottom and youngest at the top) of a given place or region.

Geophysics — Study of the earth by quantitative physical methods.

Glacier — A large, slow-moving mass of ice at least in part on land.

Graben — An elongate, relatively depressed crustal unit or block that is bounded by faults on its long sides. It is a structural form that may or may not be geomorphologically expressed as a rift valley.

Gradient — A part of a surface feature of the earth that slopes upward or downward; a slope, as of a stream channel or of a land surface.

Ground moraine — A sheet-like accumulation of glacial drift, principally till, deposited beneath a glacier to form an extensive area of low relief devoid of transverse linear features.

Groundwater — Water that is present below the ground surface in the soil and rocks of the earth's outer crust.

Group — A geologic rock unit consisting of two or more formations.

Hydrogeology — The science that deals with subsurface waters and related geologic aspects of surface waters.

Ice sheet — A glacier of considerable thickness and more than 50,000 square kilometers in area, forming a continuous cover of ice and snow over a land surface...and not confined by the underlying topography; a *continental glacier.*

Igneous — Said of a rock or mineral that solidified from molten or partly molten material, i.e., from magma.

Indurated — A compact rock or soil hardened by the action of pressure, cementation, and especially heat.
Joint — A fracture or crack in rocks along which there has been no movement of the opposing sides.
Lacustrine — Produced by or belonging to a lake.
Laurasia — A combination of Laurentia, a paleogeographic term for the Canadian Shield and its surroundings, and Eurasia. It is the protocontinent of the Northern Hemisphere, corresponding to Gondwana in the Southern Hemisphere, from which the present continents of the Northern Hemisphere have been derived by separation and continental displacement. The hypothetical supercontinent from which both were derived is *Pangea*. The protocontinent included most of North America, Greenland, and most of Eurasia, excluding India. The main zone of separation was in the North Atlantic, with a branch in Hudson Bay; geologic features on opposite sides of these zones are very similar.
Limestone — A sedimentary rock consisting primarily of calcium carbonate (the mineral, calcite).
Lithify — To change to stone, or to petrify; esp. to consolidate from a loose sediment to a solid rock.
Lithology — The description of rocks on the basis of color, structures, mineral composition, and grain size; the physical character of a rock.
Local relief — The vertical difference in elevation between the highest and lowest points of a land surface within a specified horizontal distance or in a limited area.
Loess — A homogeneous, unstratified deposit of silt deposited by the wind.
Member — A rock-stratigraphic unit of subordinate rank, comprising some specially developed part of a varied formation (e.g., a subdivision of local extent only, or a unit with the same color, hardness, composition, and other rock properties that distinguish it from adjacent units in the formation). It may be formally defined and named, informally named, or unnamed; it is not necessarily mappable.
Metamorphic rock — Any rock derived from preexisting rocks by mineralogical, chemical, and structural changes, essentially in the solid state, in response to marked changes in temperature, pressure, shearing stress, and chemical environment at depth in the earth's crust (gneisses, schists, marbles, quartzites, etc.).
Moraine — A mound, ridge, or other distinct accumulation of...glacial drift, predominantly till, deposited...in a variety of topographic landforms that are independent of control by the surface on which the drift lies.
Outwash — Stratified drift (clay, silt, sand, gravel) deposited by meltwater streams in channels, deltas, and glacial lakes, and on outwash plains and floodplains.
Outwash plain — The surface of a broad body of outwash formed in front of a glacier.
Overburden — The upper part of a sedimentary deposit, compressing and consolidating the material below; or barren rock material overlying a mineral deposit.
Pangea — A hypothetical supercontinent supposed by many geologists to have existed very early in the geologic past, and to have combined all the continental crust from which the present continents were derived by fragmentation and movement away from each other by means of some form of continental displacement. During an intermediate stage of the fragmentation, between the existence of Pangea and that of the present, widely separated continents, Pangea was supposed to have split into two large fragments, *Laurasia* on the north and *Gondwana* on the south. The proto-ocean around Pangea has been termed *Panthalassa*. Other geologists, while accepting the former existence of Laurasia and Gondwana, are reluctant to concede the existence of an original Pangea; in fact, the early (Paleozoic or older) history of continental displacement remains largely undeciphered.
Period — An interval of geologic time; a division of an era.
Physiography — The study and classification of the surface features of Earth on the basis of similarities in geologic structure and the history of geologic changes.
Physiographic province (or division) — (a) A region, all parts of which are similar in geologic structure and climate and which has consequently had a unified geologic history; (b) a region whose pattern of relief features or landforms differs significantly from that of adjacent regions.
Rank — A coal classification based on degree of metamorphism.

Relief — (a) A term used loosely for the actual physical shape, configuration, or general uneveness of a part of the earth's surface, considered with reference to variations of height and slope or to irregularities of the land surface; the elevations or differences in elevation, considered collectively, of a land surface (frequently confused with topography). (b) The vertical difference in elevation between the hilltops or mountain summits and the lowlands or valleys of a given region: "high relief" has great variation; "low relief" has little variation.

Sediment — Solid fragmental material, either inorganic or organic, that originates from weathering of rocks and is transported by, suspended in, or deposited by air, water, or ice, or that is accumulated by other natural agents, such as chemical precipitation from solution or secretion from organisms, and that forms in layers on the earth's surface at ordinary temperatures in a loose, unconsolidated form; e.g, sand, gravel, silt, mud, till, loess, alluvium.

Sedimentary rock — A rock resulting from the consolidation of loose sediment that has accumulated in layers.

Series — A geologic time-stratigraphic unit; the strata deposited during an epoch; a division of a system.

Sluiceway — An overflow channel.

Stage, substage — Geologic time-stratigraphic units; the strata formed during an age or subage, respectively.

Stratigraphy — the study, definition, and description of major and minor natural divisions of rocks, especially the study of the form, arrangement, geographic distribution, chronologic succession, classification, correlation, and mutual relationships of rock strata.

Stratigraphic unit — A stratum or body of strata recognized as a unit in the classification of the rocks of the earth's crust with respect to any specific rock character, property, or attribute or for any purpose such as description, mapping, and correlation.

Stratum, plural strata — A tabular or sheet-like mass, or a single and distinct layer, of homogeneous or gradational sedimentary material of any thickness, visually separable from other layers above and below by a discrete change in character of the material deposited or by a sharp physical break in deposition, or by both; a sedimentary *bed.*

Stylolite — A surface or contact, usually occurring in homogeneous carbonate rocks...that is marked by an irregular and interlocking penetration of the two sides; the columns, pits, and teeth-like projections on one side fit into their counterparts on the other. As usually seen in cross section, it resembles a suture or the tracing of a stylus. The seam is characterized by a concentraion of insoluble constituents of the rock...and is commonly parallel to the bedding.

System — the largest, fundamental geologic time-stratigraphic unit; the strata of a system were deposited during a period of geologic time.

Tectonic — pertaining to the global forces involved in, or the resulting structures or features of the earth's movements.

Till — Unconsolidated, nonsorted, unstratified drift deposited by and underneath a glacier and consisting of a heterogenous mixture of different sizes and kinds of rock fragments.

Till plain — The wavey surface of low relief in the area underlain by ground moraine.

Topography — The natural or physical surface features of a region, considered collectively as to form; the features revealed by the contour lines of a map.

Unconformity — A surface of erosion or nondeposition that separates younger strata from older strata; most unconformities indicate intervals of time when former areas of the sea bottom were temporarily raised above sea level.

Valley trains — The accumulations of outwash deposited by rivers in the valleys downstream from a glacier.

PLEISTOCENE GLACIATIONS IN ILLINOIS

Origin of the Glaciers

During the past million years or so, an interval of time called the Pleistocene Epoch, most of the northern hemisphere above the 50th parallel has been repeatedly covered by glacial ice. The cooling of the earth's surface, a prerequisite for glaciation, began at least 2 million years ago. On the basis of evidence found in subpolar oceans of the world (temperature-dependent fossils and oxygen-isotope ratios), a recent proposal has been made to recognize the beginning of the Pleistocene at 1.6 million years ago. Ice sheets formed in sub-arctic regions many times and spread outward until they covered the northern parts of Europe and North America. In North America, early studies of the glacial deposits led to the model that four glaciations could explain the observed distribution of glacial deposits. The deposits of a glaciation were separated from each other by the evidence of intervals of time during which soils formed on the land surface. In order of occurrence from the oldest to the youngest, they were given the names Nebraskan, Kansan, Illinoian, and Wisconsinan Stages of the Pleistocene Epoch. Work in the last 30 years has shown that there were more than four glaciations but the actual number and correlations at this time are not known. Estimates that are gaining credibility suggest that there may have been about 14 glaciations in the last one million years. In Illinois, estimates range from 4 to 8 based on buried soils and glacial deposits. For practical purposes, the previous four glacial stage model is functional, but we now know that the older stages are complex and probably contain more than one glaciation. Until we know more, all of the older glacial deposits, including the Nebraskan and Kansan will be classified as pre-Illinoian. The limits and times of the ice movement in Illinois are illustrated in the following pages by several figures.

The North American ice sheets developed when the mean annual temperature was perhaps 4° to 7°C (7° to 13°F) cooler than it is now and winter snows did not completely melt during the summers. Because the time of cooler conditions lasted tens of thousands of years, thick masses of snow and ice accumulated to form glaciers. As the ice thickened, the great weight of the ice and snow caused them to flow outward at their margins, often for hundreds of miles. As the ice sheets expanded, the areas in which snow accumulated probably also increased in extent.

Tongues of ice, called lobes, flowed southward from the Canadian centers near Hudson Bay and converged in the central lowland between the Appalachian and Rocky Mountains. There the glaciers made their farthest advances to the south. The sketch below shows several centers of flow, the general directions of flow from the centers, and the southern extent of glaciation. Because Illinois lies entirely in the central lowland, it has been invaded by glaciers from every center.

Effects of Glaciation

Pleistocene glaciers and the waters melting from them changed the landscapes they covered. The glaciers scraped and smeared the landforms they overrode, leveling and filling many of the minor valleys and even some of the larger ones. Moving ice carried colossal amounts of rock and earth, for much of what the glaciers wore off the ground was kneaded into the moving ice and carried along, often for hundreds of miles.

The continual floods released by melting ice entrenched new drainageways, deepened old ones, and then partly refilled both with sediments as great quantities of rock and earth were carried beyond the glacier fronts. According to some estimates, the amount of water drawn from the sea and changed into ice during a glaciation was enough to lower the sea level from 300 to 400 feet below present level. Consequently, the melting of a continental ice sheet provided a tremendous volume of water that eroded and transported sediments.

In most of Illinois, then, glacial and meltwater deposits buried the old rock-ribbed, low, hill-and-valley terrain and created the flatter landforms of our prairies. The mantle of soil material and the buried deposits of gravel, sand, and clay left by the glaciers over about 90 percent of the state have been of incalculable value to Illinois residents.

Glacial Deposits

The deposits of earth and rock materials moved by a glacier and deposited in the area once covered by the glacier are collectively called **drift**. Drift that is ice-laid is called **till**. Water-laid drift is called **outwash**.

Till is deposited when a glacier melts and the rock material it carries is dropped. Because this sediment is not moved much by water, a till is unsorted, containing particles of different sizes and compositions. It is also stratified (unlayered). A till may contain materials ranging in size from microscopic clay particles to large boulders. Most tills in Illinois are pebbly clays with only a few boulders. For descriptive purposes, a mixture of clay, silt, sand and boulders is called **diamicton**. This is a term used to describe a deposit that could be interpreted as till or a mass wasting product.

Tills may be deposited as **end moraines**, the arc-shaped ridges that pile up along the glacier edges where the flowing ice is melting as fast as it moves forward. Till also may be deposited as **ground moraines**, or **till plains**, which are gently undulating sheets deposited when the ice front melts back, or retreats. Deposits of till identify areas once covered by glaciers. Northeastern Illinois has many alternating ridges and plains, which are the succession of end moraines and till plains deposited by the Wisconsinan glacier.

Sorted and stratified sediment deposited by water melting from the glacier is called **outwash**. Outwash is bedded, or layered, because the flow of water that deposited it varied in gradient, volume, velocity, and direction. As a meltwater stream washes the rock materials along, it sorts them by size—the fine sands, silts, and clays are carried farther downstream than the coarser gravels and cobbles. Typical Pleistocene outwash in Illinois is in multilayered beds of clays, silts, sands, and gravels that look much like modern stream deposits in some places. In general, outwash tends to be coarser and less weathered, and alluvium is most often finer than medium sand and contains variable amounts of weathered material.

Outwash deposits are found not only in the area covered by the ice field but sometimes far beyond it. Meltwater streams ran off the top of the glacier, in crevices in the ice, and under the ice. In some places, the cobble-gravel-sand filling of the bed of a stream that flowed in the ice is preserved as a sinuous ridge called an **esker**. Some eskers in Illinois are made up of sandy to silty deposits and contain mass wasted diamicton material. Cone-shaped mounds of coarse outwash, called **kames**, were formed where meltwater plunged through crevasses in the ice or into ponds on the glacier.

The finest outwash sediments, the clays and silts, formed bedded deposits in the ponds and lakes that filled glacier-dammed stream valleys, the sags of the till plains, and some low, moraine-diked till plains. Meltwater streams that entered a lake rapidly lost speed and also quickly dropped the sands and gravels they carried, forming deltas at the edge of the lake. Very fine sand and silts were commonly redistributed on the lake bottom by wind-generated currents, and the clays, which stayed in suspension longest, slowly settled out and accumulated with them.

Along the ice front, meltwater ran off in innumerable shifting and short-lived streams that laid down a broad, flat blanket of outwash that formed an **outwash plain**. Outwash was also carried away from the glacier in valleys cut by floods of meltwater. The Mississiippi, Illinois, and Ohio Rivers occupy valleys that were major channels for meltwaters and were greatly widened and deepened during times of the greatest meltwater floods. When the floods waned, these valleys were partly filled with outwash far beyond the ice margins. Such outwash deposits, largely sand and gravel, are known as **valley trains**. Valley train deposits may be both extensive and thick. For instance, the long valley train of the Mississippi Valley is locally as much as 200 feet thick.

Loess, Eolian Sand and Soils

One of the most widespread sediments resulting from glaciation was carried not by ice or water but by wind. **Loess** is the name given to windblown deposits dominated by silt. Most of the silt was derived from wind erosion of the valley trains. Wind action also sorted out **eolian sand** which commonly formed **sand dunes** on the valley trains or on the adjacent uplands. In places, sand dunes have migrated up to 10 miles away from the principle source of sand. Flat areas between dunes are generally underlain by eolian **sheet sand** that is commonly reworked by water action. On uplands along the major valley trains, loess and eolian sand are commonly interbedded. With increasing distance from the valleys, the eolian sand pinches out, often within one mile.

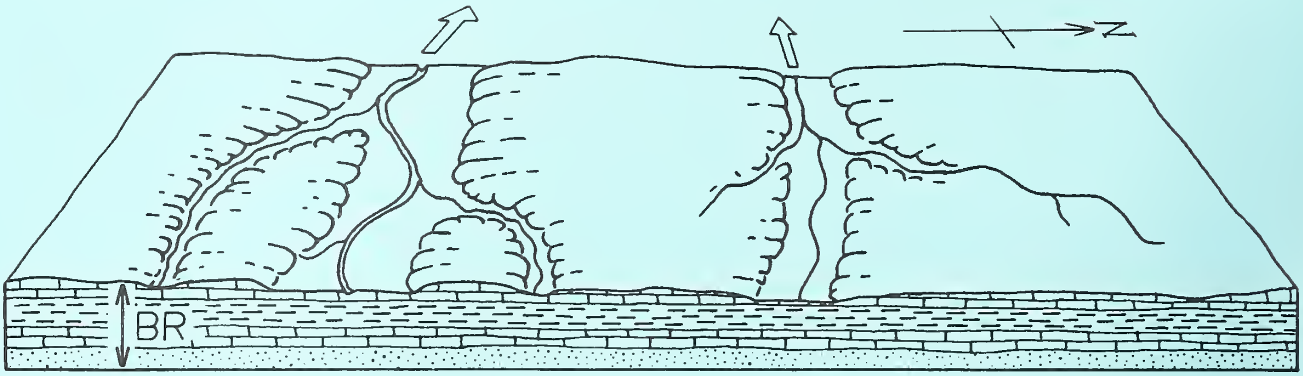
Eolian deposition occurred when certain climatic conditions were met, probably in a seasonal pattern. Deposition could have occurred in the fall, winter or spring season when low precipitation rates and low temperatures caused meltwater floods to abate, exposing the surfaces of the valley trains and permitting them to dry out. During Pleistocene time, as now, west winds prevailed, and the loess deposits are thickest on the east sides of the source valleys. The loess thins rapidly away from the valleys but extends over almost all the state.

Each Pleistocene glaciation was followed by an interglacial stage that began when the climate warmed enough to melt the glaciers and their snowfields. During these warmer intervals, when the climate was similar to that of today, drift and loess surfaces were exposed to weather and the activities of living things. Consequently, over most of the glaciated terrain, soils developed on the Pleistocene deposits and altered their composition, color, and texture. Such soils were generally destroyed by later glacial advances, but some were buried. Those that survive serve as “key beds,” or stratigraphic markers, and are evidence of the passage of a long interval of time.

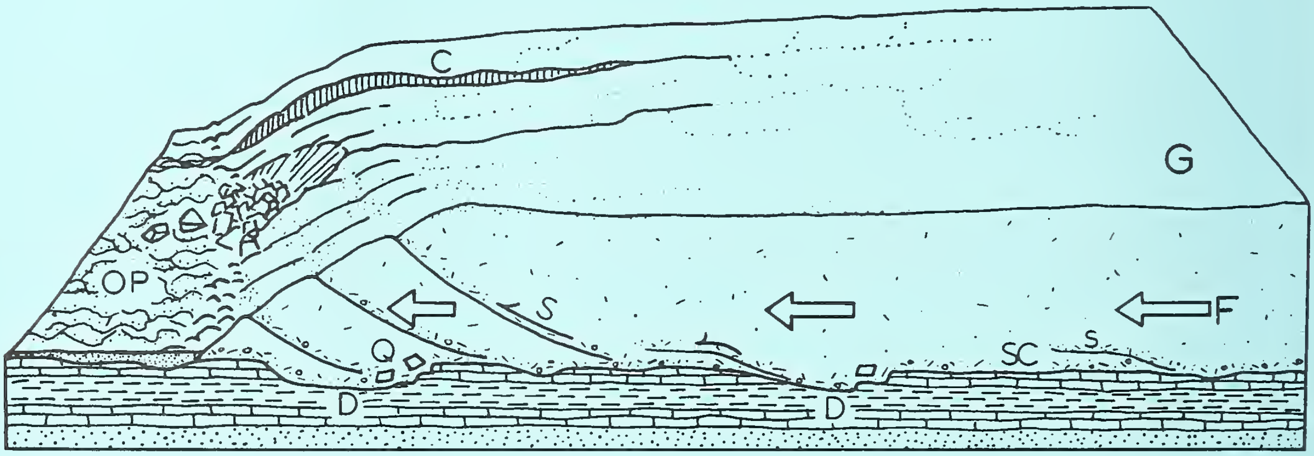
Glaciation in a Small Illinois Region

The following diagrams show how a continental ice sheet might have looked at various stages as it moved across a small region in Illinois. They illustrate how it could change the old terrain and create a landscape like the one we live on. To visualize how these glaciers looked, geologists study the landforms and materials left in the glaciated regions and also the present-day mountain glaciers and polar ice caps.

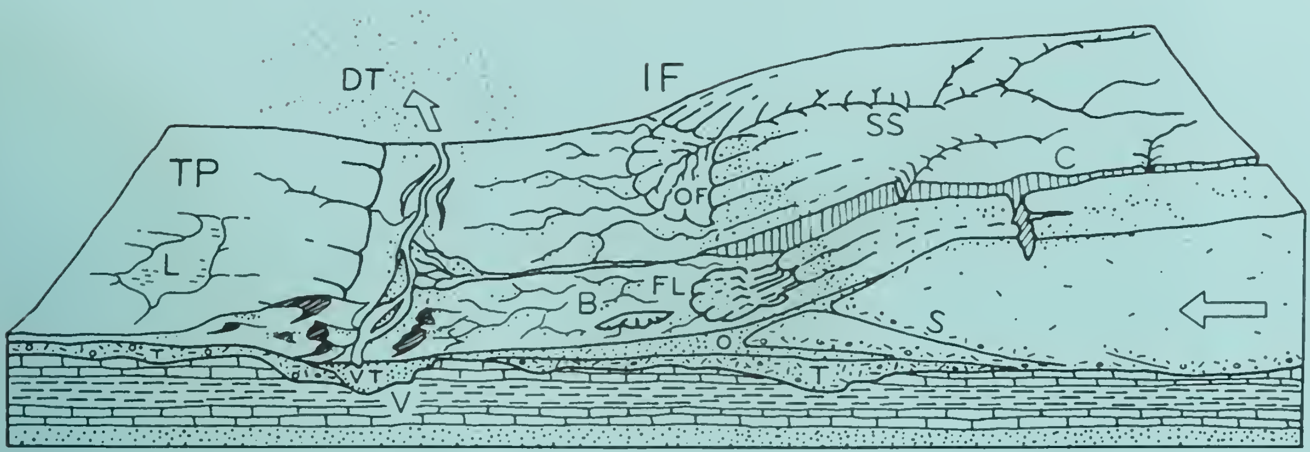
The block of land in the diagrams is several miles wide and about 10 miles long. The vertical scale is exaggerated—layers of material are drawn thicker and landforms higher than they ought to be so that they can be easily seen.



1. **The Region Before Glaciation** — Like most of Illinois, the region illustrated is underlain by almost flat-lying beds of sedimentary rocks—layers of sandstone ( ), limestone ( ), and shale ( ). Millions of years of erosion have planed down the bedrock (BR), creating a terrain of low uplands and shallow valleys. A residual soil weathered from local rock debris covers the area but is too thin to be shown in the drawing. The streams illustrated here flow westward and the one on the right flows into the other at a point beyond the diagram.



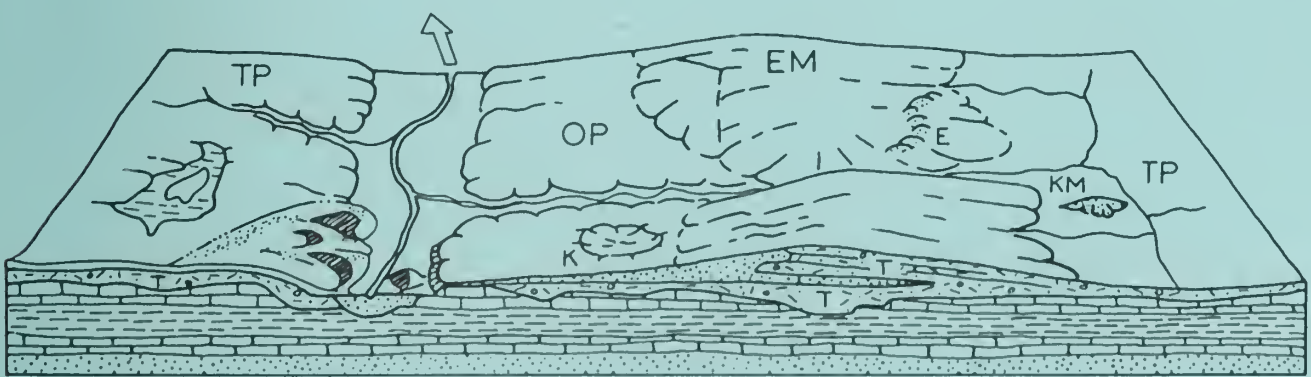
2. **The Glacier Advances Southward** — As the Glacier (G) spreads out from its ice snowfield accumulation center, it scours (SC) the soil and rock surface and quarries (Q)—pushes and plucks up—chunks of bedrock. The materials are mixed into the ice and make up the glacier's "load." Where roughnesses in the terrain slow or stop flow (F), the ice "current" slides up over the blocked ice on innumerable shear planes (S). Shearing mixes the load very thoroughly. As the glacier spreads, long cracks called "crevasses" (C) open parallel to the direction of ice flow. The glacier melts as it flows forward, and its meltwater erodes the terrain in front of the ice, deepening (D) some old valleys before ice covers them. Meltwater washes away some of the load freed by melting and deposits it on the outwash plain (OP). The advancing glacier overrides its outwash and in places scours much of it up again. The glacier may be 5000 or so feet thick, and tapers to the margin, which was probably in the range of several hundred feet above the old terrain. The ice front advances perhaps as much as a third of a mile per year.



3. **The Glacier Deposits an End Moraine** — After the glacier advances across the area, the climate warms and the ice begins to melt as fast as it advances. The ice front (IF) is now stationary, or fluctuating in a narrow area, and the glacier is depositing an end moraine.

As the top of the glacier melts, some of the sediment that is mixed in the ice accumulates on top of the glacier. Some is carried by meltwater onto the sloping ice front (IF) and out onto the plain beyond. Some of the debris slips down the ice front in a mudflow (FL). Meltwater runs through the ice in a crevasse (C). A supraglacial stream (SS) drains the top of the ice, forming an outwash fan (OF). Moving ice has overridden an immobile part of the front on a shear plane (S). All but the top of a block of ice (B) is buried by outwash (O).

Sediment from the melted ice of the previous advance (figure 2) remains as a till layer (T), part of which forms the till plain (TP). A shallow, marshy lake (L) fills a low place in the plain. Although largely filled with drift, the valley (V) remains a low spot in the terrain. As soon as the ice cover melts, meltwater drains down the valley, cutting it deeper. Later, outwash partly refills the valley: the outwash deposit is called a valley train (VT). Wind blows dust (DT) off the dry floodplain. The dust will form a loess deposit when it settles. Sand dunes (D) form on the south and east sides of streams.



4. **The Region after Glaciation** — As the climate warms further, the whole ice sheet melts, and glaciation ends. The end moraine (EM) is a low, broad ridge between the outwash plain (OP) and till plains (TP). Run-off from rains cuts stream valleys into its slopes. A stream goes through the end moraine along the channel cut by the meltwater that ran out of the crevasse in the glacier.

Slopewash and vegetation are filling the shallow lake. The collapse of outwash into the cavity left by the ice block's melting has made a kettle (K). The outwash that filled a tunnel draining under the glacier is preserved in an esker (E). The hill of outwash left where meltwater dumped sand and gravel into a crevasse or other depression in the glacier or at its edge is a kame (KM). A few feet of loess covers the entire area but cannot be shown at this scale.

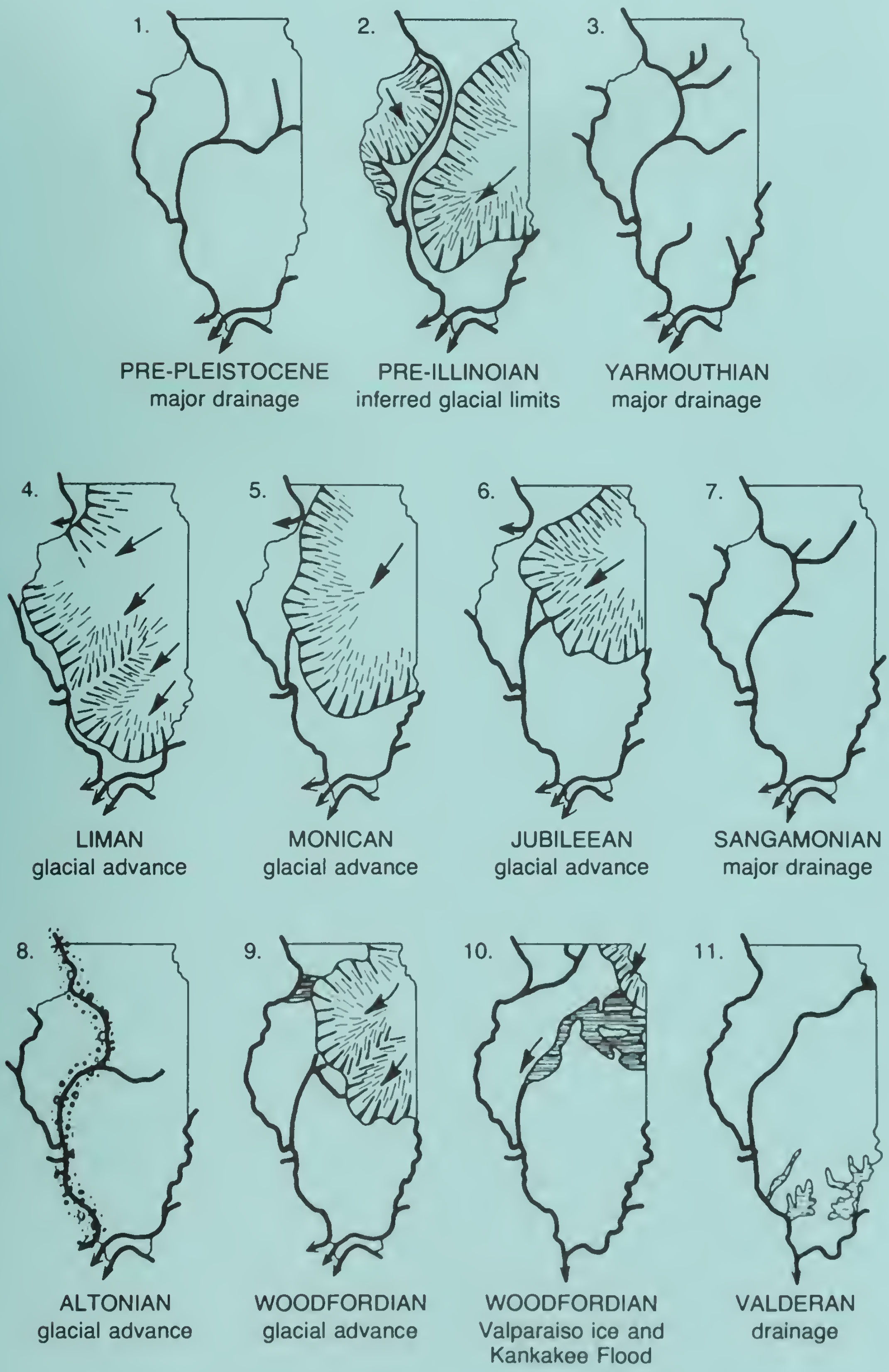
TIME TABLE OF PLEISTOCENE GLACIATION

		STAGE		SUBSTAGE	NATURE OF DEPOSITS	SPECIAL FEATURES
QUATERNARY		HOLOCENE (interglacial)		Years Before Present	Soil, youthful profile of weathering, lake and river deposits, dunes, peat	
				10,000		
	Pleistocene	WISCONSINAN (glacial)	late	Valderan	Outwash, lake deposits	Outwash along Mississippi Valley
				11,000		
				Twocreekan	Peat and alluvium	Ice withdrawal, erosion
				12,500		
				Woodfordian	Drift, loess, dunes, lake deposits	Glaciation; building of many moraines as far south as Shelbyville; extensive valley trains, outwash plains, and lakes
				25,000		
			mid	Farmdalian	Soil, silt, and peat	Ice withdrawal, weathering, and erosion
				28,000		
			early	Altonian	Drift, loess	Glaciation in Great Lakes area, valley trains along major rivers
				75,000		
		SANGAMONIAN (interglacial)			Soil, mature profile of weathering	Important stratigraphic marker
				125,000		
		ILLINOIAN (glacial)		Jubileean	Drift, loess, outwash	Glaciers from northeast at maximum reached Mississippi River and nearly to southern tip of Illinois
				Monican	Drift, loess, outwash	
				Liman	Drift, loess, outwash	
				300,000?		
		YARMOUTHIAN (interglacial)			Soil, mature profile of weathering	Important stratigraphic marker
				500,000?		
		Pre-Illinoian: KANSAN* (glacial)			Drift, loess	Glaciers from northeast and northwest covered much of state
				700,000?		
		Pre-Illinoian: AFTONIAN* (interglacial)			Soil, mature profile of weathering	(hypothetical)
				900,000?		
		Pre-Illinoian: NEBRASKAN* (glacial)			Drift (little known)	Glaciers from northwest invaded western Illinois
				1,600,000 or more		

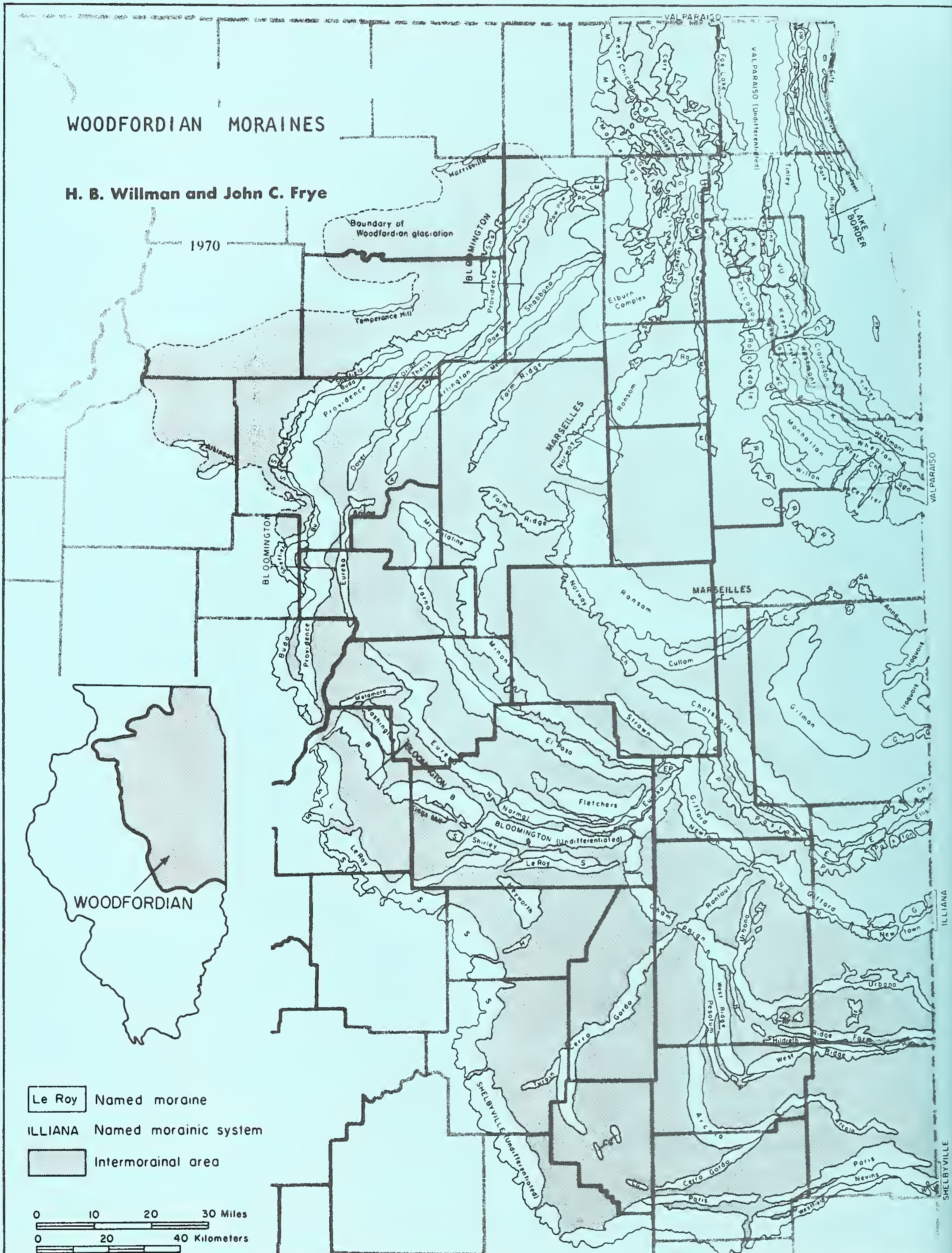
*Old oversimplified concepts, now known to represent a series of glacial cycles.

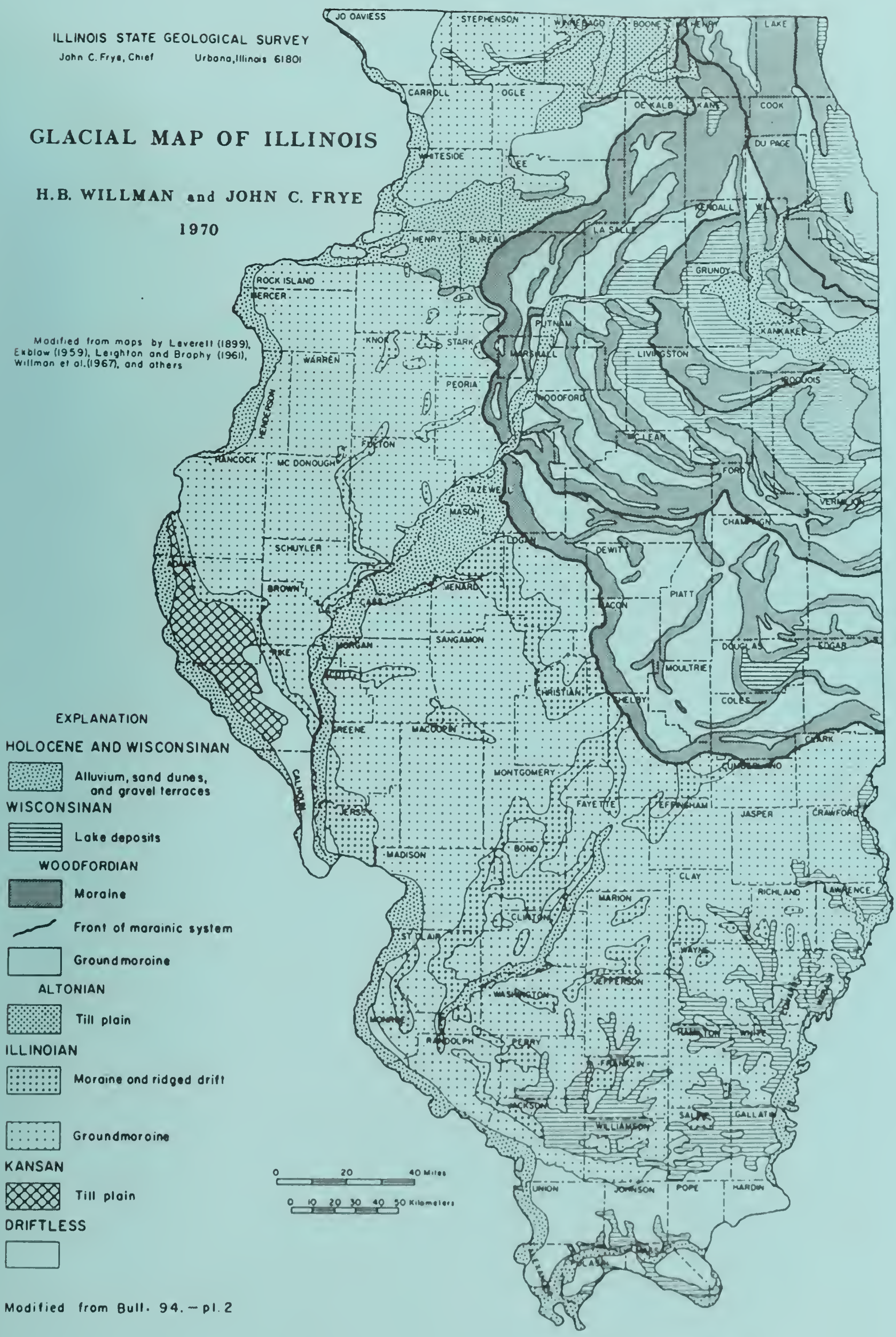
(Illinois State Geological Survey, 1973)

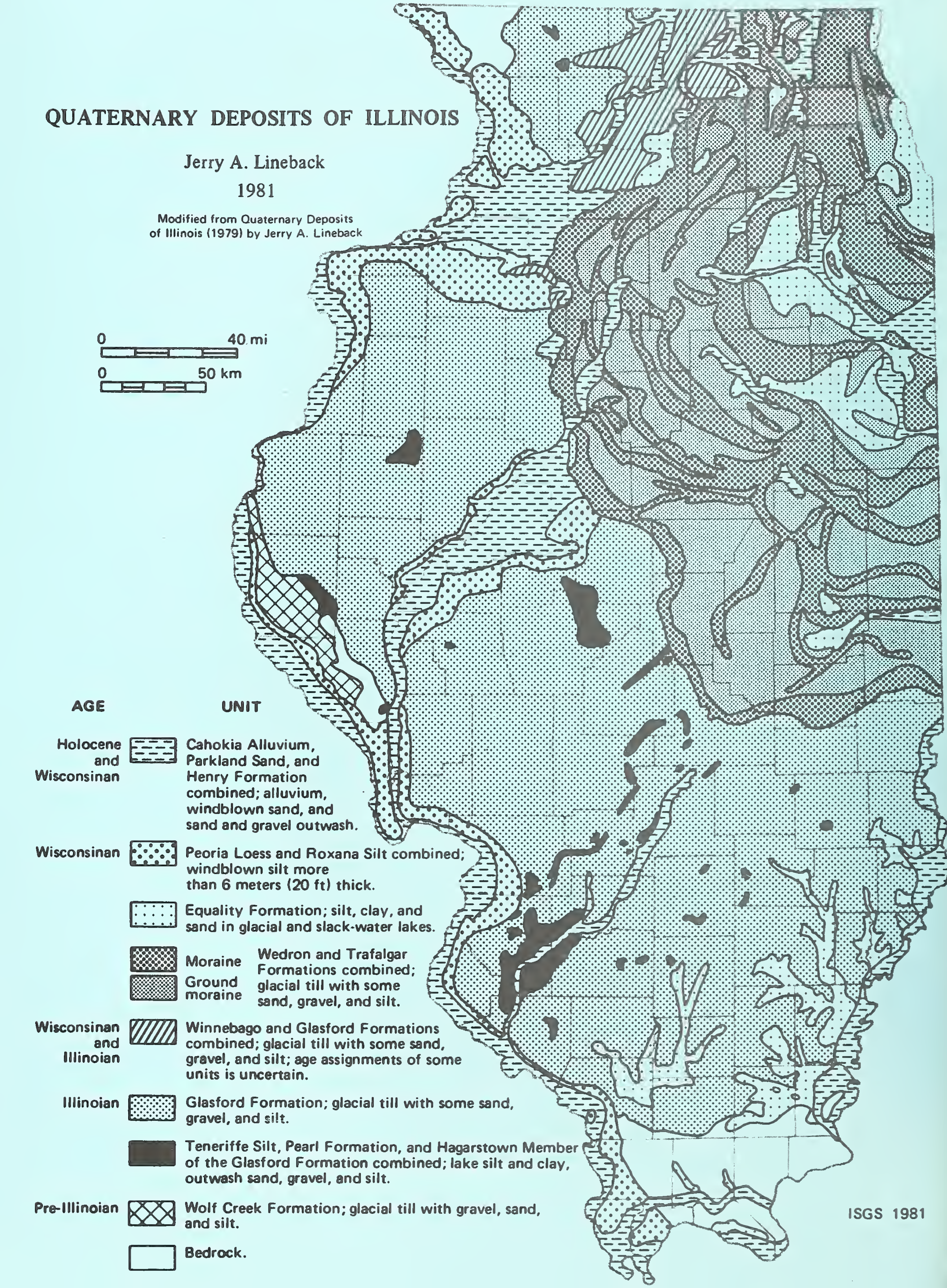
SEQUENCE OF GLACIATIONS AND INTERGLACIAL DRAINAGE IN ILLINOIS



(Modified from Willman and Frye, "Pleistocene Stratigraphy of Illinois," ISGS Bull. 94, fig. 5, 1970.)


WOODFORDIAN MORAINES
H. B. Willman and John C. Frye
1970
Boundary of Woodfordian glaciation
WOODFORDIAN
Le Roy Named moraine
ILLIANA Named morainic system
Intermorainal area
0 10 20 30 Miles
0 20 40 Kilometers
VALPARAISO
BLOOMINGTON
MARSEILLES
LAKE BORDER
ILLIANA
SHELBYVILLE
Temperance Hill
Providence
Shabbona
Farm Ridge
Ransom
Elburn Complex
Minonk
Varna
Eureka
Cullom
Chatsworth
Gilman
Iroquois
El Paso
Fletchers
Normal
BLOOMINGTON (Undifferentiated)
Shirley
Le Roy
Rantoul
Urbana
West Ridge
Pesotum
Cerro Gordo
Arcola
Paris
Nevins
Westfield
SHELBYVILLE (Undifferentiated)
VALPARAISO (Undifferentiated)
Manhattan
Wilton
Tinley
Newtown
Gifford
Paxton
Ellis
Hildreth
Ridge Farm
Metamora
Dover
Buda
Sheffield
Atkinson
Norway
Mt Palatine
Bloomington
Marseilles


ILLINOIS STATE GEOLOGICAL SURVEY
John C. Frye, Chief
Urbana, Illinois 61801
GLACIAL MAP OF ILLINOIS
H.B. WILLMAN and JOHN C. FRYE
1970
Modified from maps by Leverett (1899), Ekblaw (1959), Leighton and Brophy (1961), Willman et al. (1967), and others
EXPLANATION
HOLOCENE AND WISCONSINAN
Alluvium, sand dunes, and gravel terraces
WISCONSINAN
Lake deposits
WOODFORDIAN
Moraine
Front of morainic system
Groundmoraine
ALTONIAN
Till plain
ILLINOIAN
Moraine and ridged drift
Groundmoraine
KANSAN
Till plain
DRIFTLESS
Modified from Bull. 94.—pl. 2
0
20
40 Miles
0
10
20
30
40
50 Kilometers
JO DAVIESS
STEPHENSON
WINNEBAGO
BOONE
LAKE
CARROLL
OGLE
DE KALB
KANE
COOK
DU PAGE
WHITESIDE
KENDALL
LA SALLE
HENRY
BUREAU
GRUNDY
ROCK ISLAND
MERCER
PUTNAM
KANKAKEE
KNOX
STARK
MARSHALL
LIVINGSTON
WARREN
PEORIA
IROQUOIS
WOODFORD
HENDERSON
MC LEAN
FULTON
HANCOCK
MC DONOUGH
FORD
TAZEWELL
VERMILION
MASON
CHAMPAIGN
SCHUYLER
LOGAN
DEWITT
ADAMS
BROWN
MENARD
PIATT
CASS
MORGAN
SANGAMON
PIKE
DOUGLAS
EDGAR
SCOTT
MOULTRIE
CHRISTIAN
SHELBY
COLES
GREENE
MACOUPIN
CLARK
CUMBERLAND
MONTGOMERY
CALHOUN
FAYETTE
EFFINGHAM
JASPER
CRAWFORD
JERSEY
BOND
MADISON
CLAY
MARION
RICHLAND
LAWRENCE
CLINTON
ST CLAIR
WAYNE
JEFFERSON
WASHINGTON
MONROE
HAMILTON
WHITE
RANDOLPH
PERRY
FRANKLIN
JACKSON
WILLIAMSON
SALINE
GALLATIN
UNION
JOHNSON
POPE
HARDIN



QUATERNARY DEPOSITS OF ILLINOIS
Jerry A. Lineback
1981
Modified from Quaternary Deposits of Illinois (1979) by Jerry A. Lineback
0
40 mi
0
50 km
AGE
UNIT
Holocene and Wisconsinan
Cahokia Alluvium, Parkland Sand, and Henry Formation combined; alluvium, windblown sand, and sand and gravel outwash.
Wisconsinan
Peoria Loess and Roxana Silt combined; windblown silt more than 6 meters (20 ft) thick.
Equality Formation; silt, clay, and sand in glacial and slack-water lakes.
Moraine
Ground moraine
Wedron and Trafalgar Formations combined; glacial till with some sand, gravel, and silt.
Wisconsinan and Illinoian
Winnebago and Glasford Formations combined; glacial till with some sand, gravel, and silt; age assignments of some units is uncertain.
Illinoian
Glasford Formation; glacial till with some sand, gravel, and silt.
Teneriffe Silt, Pearl Formation, and Hagarstown Member of the Glasford Formation combined; lake silt and clay, outwash sand, gravel, and silt.
Pre-Illinoian
Wolf Creek Formation; glacial till with gravel, sand, and silt.
Bedrock.
ISGS 1981

ILLINOIS STATE GEOLOGICAL SURVEY
Urbana, Illinois 61801

GEOGRAM 2
October 1974

ERRATICS ARE ERRATIC

Myrna M. Killey

You may have seen them scattered here and there in Illinois—boulders, some large, some small, lying alone or with a few companions in the corner of a field, at the edge of a road, in someone's yard, or perhaps on a courthouse lawn or schoolyard. Many of them seem out of place, like rough, alien monuments in the stoneless, grassy knolls and prairies of our state. Some—the colorful and glittering granites, banded gneisses, and other intricately veined and streaked igneous and metamorphic rocks—are indeed foreign rocks, for they came from Canada and the states north of us. Others—gray and tan sedimentary rocks—are native rocks and may be no more than a few miles from their place of origin. All of these rocks are glacial boulders that were moved to their present sites by massive ice sheets that flowed across our state. If these boulders are unlike the rocks in the quarries and outcrops in the region where they are found, they are called erratics.

The continental glaciers of the Great Ice Age scoured and scraped the land surface as they advanced, pushing up chunks of bedrock and grinding them against each other or along the ground surface as the rock-laden ice sheets pushed southward. Hundreds of miles of such grinding, even on such hard rocks as granite, eventually rounded off the sharp edges of these passengers in the ice until they became the rounded, irregular boulders we see today. Although we do not know the precise manner in which erratics reached their present isolated sites, many were probably dropped directly from the melting front of a glacier. Others may have been rafted to their present resting places by icebergs on ancient lakes or on the floodwaters of some long-vanished stream as it poured from a glacier. Still others, buried in the glacial deposits, could have worked their way up to the land surface as the surrounding loose soil repeatedly froze and thawed. When the freezing ground expands, pieces of rock tend to be pushed upward, where they are more easily reached by the farmer's plow and also more likely to be exposed by erosion.

An eight-foot boulder of pink granite left by a glacier in the bed of a creek about 5 miles southwest of Alexis, Warren County, Illinois. (From ISGS Bulletin 57, 1929.)

Generally speaking, erratics found northeast of a line drawn from Freeport in Stephenson County, southward through Peoria, and then southeastward through Shelbyville to Marshall at the east edge of the state were brought in by the last glacier to enter Illinois. This glaciation, called the Wisconsinan, spread southwestward into Illinois from a center in eastern Canada, reaching our state about 75,000 years ago and (after repeated advances and retreats of the ice margin) melting from the state about 12,500 years ago. Erratics to the west or south of the great arc outlined above were brought in by a much older glacier, the Illinoian, which spread over most of the state about 300,000 to 175,000 years ago. Some erratics were brought in by even older glaciers that came from the northwest.

You may be able to locate some erratics in your neighborhood. Sometimes it is possible to tell where the rock originally came from by determining the kind of rock it is. A large boulder of granite, gneiss, or other igneous or metamorphic rock may have come from the Canadian Shield, a vast area in central and eastern Canada where rocks of Precambrian age (more than 600 million years old) are exposed at the surface. Some erratics containing flecks of copper were probably transported here from the "Copper Range" of the upper peninsula of Michigan. Large pieces of copper have been found in glacial deposits of central and northern Illinois. Light gray to white quartzite boulders with beautiful, rounded pebbles of red jasper came from a very small outcrop area near Bruce Mines, Ontario, Canada. Purplish pieces of quartzite, some of them banded, probably originated in the Baraboo Range of central Wisconsin. Most interesting of all are the few large boulders of Canadian tillite. Tillite is lithified (hardened into rock) glacial till deposited by a Precambrian glacier many millions of years older than the ones that invaded our state a mere few thousand years ago. Glacial till is an unsorted and unlayered mixture of clay, sand, gravel, and boulders that vary widely in size and shape. Tillite is a gray to greenish gray rock containing a mixture of grains of different sizes and scattered pebbles of various types and sizes.

Many erratics are of notable size and beauty, and in parts of Illinois they are commonly used in landscaping. Some are used as monuments in courthouse squares, in parks, or along highways. Many are marked with metal plaques to indicate an interesting historical spot or event. Keep an eye out for erratics. There may be some of these glacial strangers in your neighborhood that would be interesting to know.

ILLINOIS STATE GEOLOGICAL SURVEY
Urbana, Illinois 61801

GEOGRAM 5
October 1975

ANCIENT DUST STORMS IN ILLINOIS

Myrna M. Killey

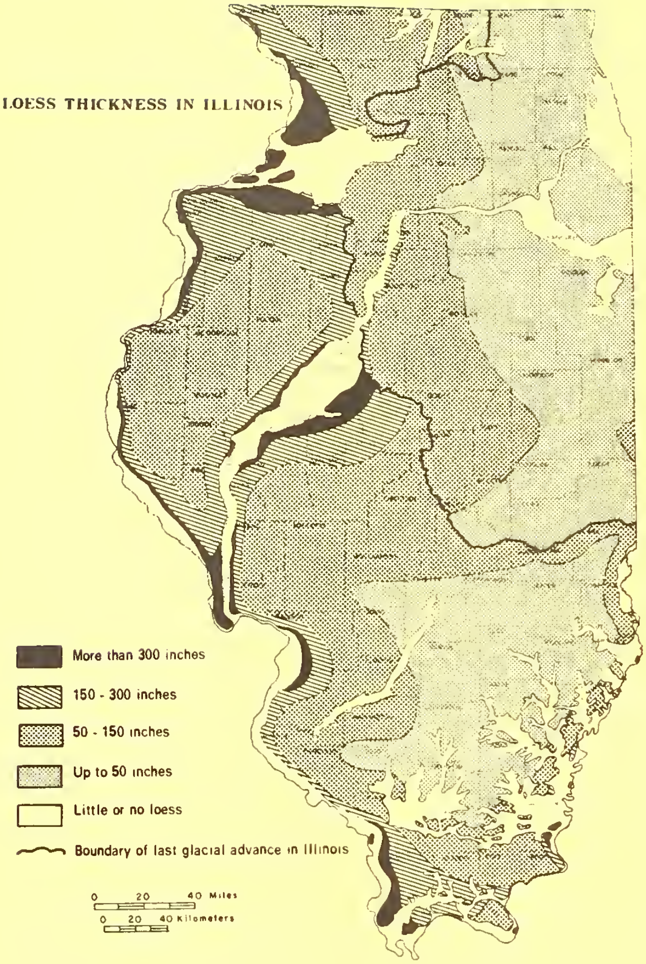
Fierce dust storms whirled across Illinois long before human beings were here to record them. Where did all the dust come from? Geologists have carefully put together clues from the earth itself to get the story. As the glaciers of the Great Ice Age scraped and scoured their way southward across the landscape from Canada, they moved colossal amounts of rock and earth. Much of the rock ground from the surface was kneaded into the ice and carried along, often for hundreds of miles. The glaciers acted as giant grist mills, grinding much of the rock and earth to "flour"—very fine dust-sized particles.

During the warm seasons, water from the melting ice poured from the glacier front, laden with this rock flour, called silt. In the cold months the meltwater stopped flowing and the silt was left along the channels the water had followed, where it dried out and became dust. Strong winds picked up the dust, swept it from the floodplains, and carried it to adjacent uplands. There the forests along the river valleys trapped the dust, which became part of the moist forest soil. With each storm more material accumulated until the high bluffs adjacent to major rivers were formed. The dust deposits are thicker along the eastern sides of the valleys than they are on the western sides, a fact from which geologists deduce that the prevailing winds of that time blew from west to east, the same direction as those of today. From such clues geologists conclude that the geologic processes of the past were much like those of today.

The deposits of windblown silt are called loess (rhymes with "bus"). Loess is found not only in the areas once covered by the glaciers but has been blown into the nonglaciated areas. The glaciers, therefore, influenced the present land surface well beyond the line of their farthest advance.

Loess has several interesting characteristics. Its texture is so fine and uniform that it can easily be identified in roadcuts—and because it blankets such a vast area many roads are cut through it. Even more noticeable is its tendency to stand in vertical walls. These steep walls develop as the loess drains and becomes tough, compact, and massive, much like a rock. Sometimes cracks develop in the loess, just as they do in massive limestones and sandstones. Loess makes good highway banks if it is cut vertically. A vertical cut permits maximum drainage because little surface is exposed to rain, and rainwater tends to drain straight down through it to the rock underneath. If the bank is cut at an angle more water soaks in, which causes the loess to slump down. Along Illinois roads the difference between a loess roadcut and one in ordinary glacial till is obvious. The loess has a very uniform texture, while the till is composed of a random mixture of rock debris, from clay and silt through cobbles and boulders.

Many loess deposits are worth a close look. Through a 10-power hand lens separate grains can be seen, among them many clear, glassy, quartz grains. Some loess deposits contain numerous rounded, lumpy stones called concretions. Their formation began when water percolating through the loess dissolved tiny



limestone grains. Some of the dissolved minerals later became solid again, gathering around a tiny nucleus or along roots to form the lumpy masses. A few such concretions are shaped roughly like small dolls and, from this resemblance, are called "loess kindchen," a German term meaning "loess children." They may be partly hollow and contain smaller lumps that make them rattle when shaken.

Fossil snails can be found in some loess deposits. The snails lived on the river bluffs while the loess was being deposited and were buried by the dust. When they are abundant, they are used to determine how old the loess is. The age is found by measuring the amount of radioactive carbon in the calcium carbonate of their shells.

Some of the early loess deposits were covered by new layers of loess following later glacial invasions. Many thousands of years passed between the major glacial periods, during which time the climate was as warm as that of today. During the warm intervals, the surface of the loess and other glacial deposits was exposed to weather. Soils developed on most of the terrain, altering the composition, color, and texture of the glacial material. During later advances of the ice, some of these soils were destroyed, but in many places they are preserved under the younger sediments. Such ancient buried soils can be used to determine when the materials above and below them were laid down by the ice and what changes in climate took place.

The blanket of loess deposited by the ancient dust storms forms the parent material of the rich, deep soils that today are basic to the state's agriculture. A soil made of loess crumbles easily and has great moisture-holding capacity. It also is free from rocks that might complicate cultivation. Those great dust storms that swirled over the land many thousands of years ago thus endowed Illinois with one of its greatest resources, its highly productive soil.

DEPOSITIONAL HISTORY OF THE PENNSYLVANIAN ROCKS IN ILLINOIS

At the close of the Mississippian Period, about 310 million years ago, the sea withdrew from the Midcontinent region. A long interval of erosion that took place early in Pennsylvanian time removed hundreds of feet of the pre-Pennsylvanian strata, completely stripping them away and cutting into older rocks over large areas of the Midwest. Ancient river systems cut deep channels into the bedrock surface. Later, but still during early Pennsylvanian (Morrowan) time, the sea level started to rise; the corresponding rise in the base level of deposition interrupted the erosion and led to filling the valleys in the erosion surface with fluvial, brackish, and marine sands and muds.

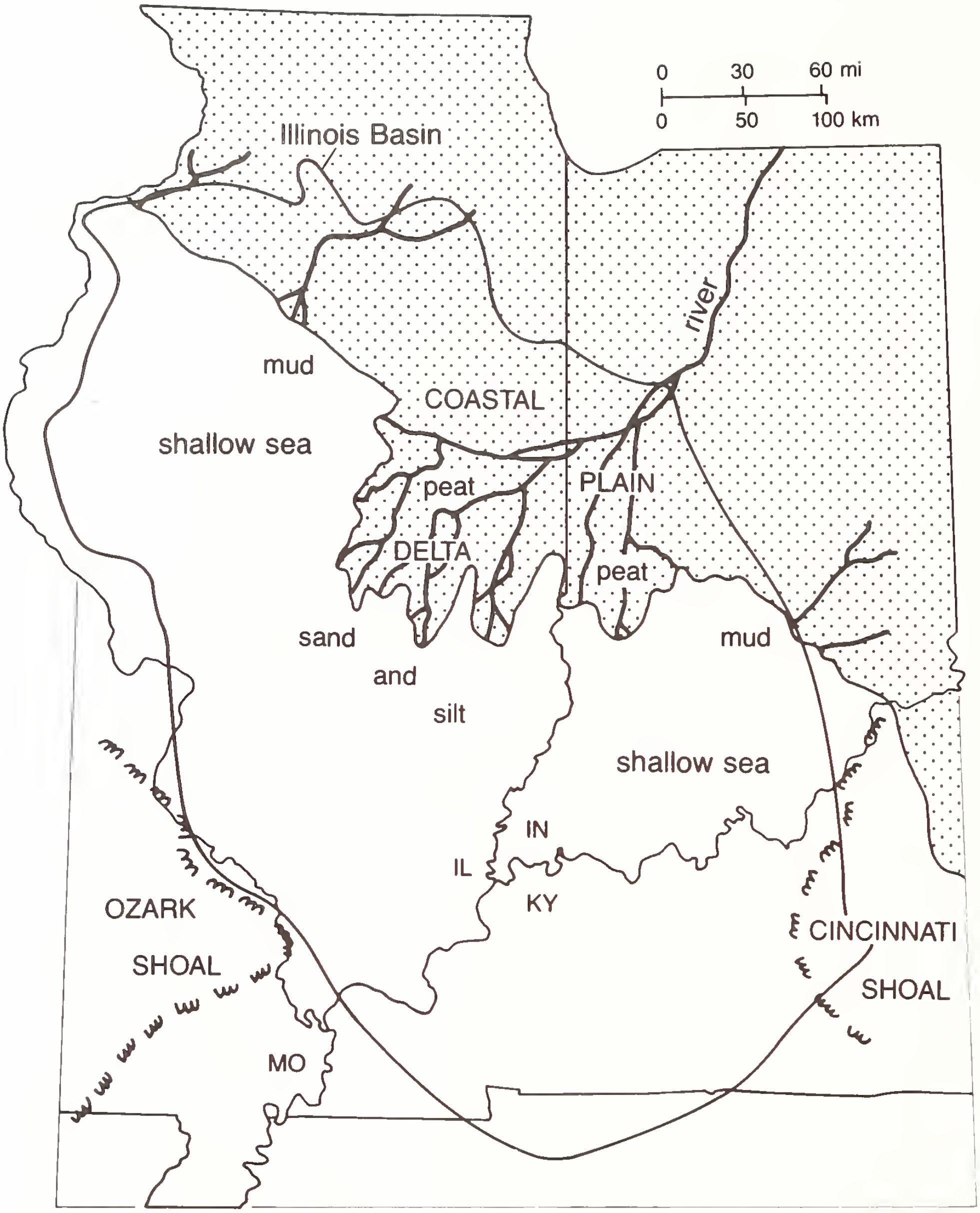
Depositional conditions in the Illinois Basin during the Pennsylvanian Period were somewhat similar to those of the preceding Chesterian (late Mississippian) time. A river system flowed southwestward across a swampy lowland, carrying mud and sand from highlands to the northeast. This river system formed thin but widespread deltas that coalesced into a vast coastal plain or lowland that prograded (built out) into the shallow sea that covered much of present-day Illinois (see paleogeographic map, next page). As the lowland stood only a few feet above sea level, slight changes in relative sea level caused great shifts in the position of the shoreline.

During most of Pennsylvanian time, the Illinois Basin gradually subsided; a maximum of about 3000 feet of Pennsylvanian sediments are preserved in the basin. The locations of the delta systems and the shoreline of the resulting coastal plain shifted, probably because of worldwide sea level changes, coupled with variation in the amounts of sediments provided by the river system and local changes in basin subsidence rates. These frequent shifts in the coastline position caused the depositional conditions at any one locality in the basin to alternate frequently between marine and nonmarine, producing a variety of lithologies in the Pennsylvanian rocks (see lithology distribution chart).

Conditions at various places on the shallow sea floor favored the deposition of sand, lime mud, or mud. Sand was deposited near the mouths of distributary channels, where it was reworked by waves and spread out as thin sheets near the shore. Mud was deposited in quiet-water areas — in delta bays between distributaries, in lagoons behind barrier bars, and in deeper water beyond the nearshore zone of sand deposition. Limestone was formed from the accumulation of limy parts of plants and animals laid down in areas where only minor amounts of sand and mud were being deposited. The areas of sand, mud, and limy mud deposition continually changed as the position of the shoreline changed and as the delta distributaries extended seaward or shifted their positions laterally along the shore.

Nonmarine sand, mud, and lime mud were deposited on the coastal plain bordering the sea. The nonmarine sand was deposited in delta distributary channels, in river channels, and on the broad floodplains of the rivers. Some sand bodies 100 or more feet thick were deposited in channels that cut through the underlying rock units. Mud was deposited mainly on floodplains. Some mud and freshwater lime mud were deposited locally in fresh-water lakes and swamps.

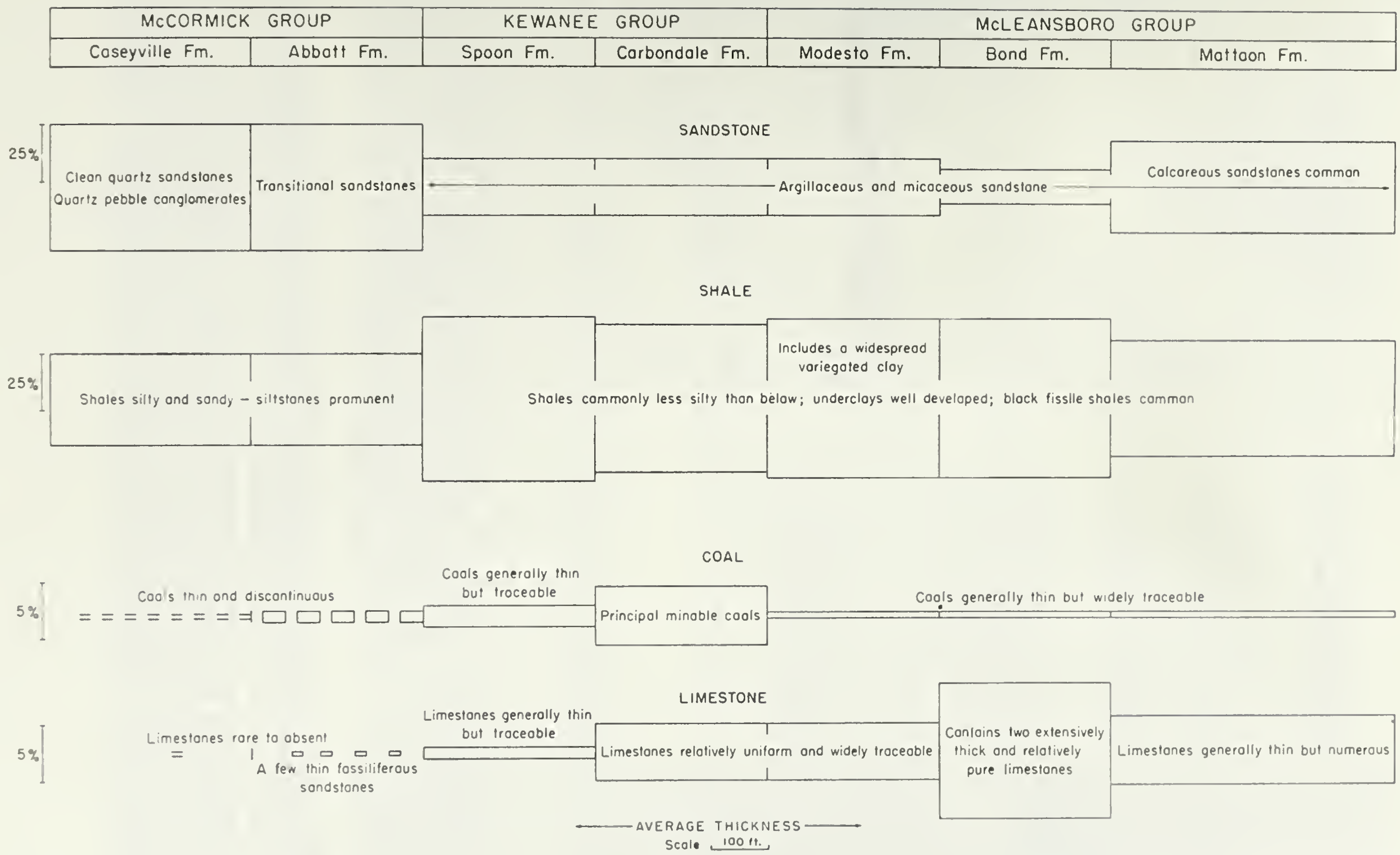
Beneath the quiet water of extensive swamps that prevailed for long intervals on the emergent coastal lowland, peat was formed by accumulation of plant material. Lush forest vegetation covered the region; it thrived in the warm, moist Pennsylvanian-age climate. Although the origin of the underclays beneath the coal is not precisely known, most evidence indicates that they were deposited in the swamps as slackwater mud before the accumulation of much plant debris. The clay underwent modification to become the soil upon which the lush vegetation grew in the swamps. Underclay frequently contains plant roots and rootlets that appear to be in their original places. The vast swamps were the culmination of nonmarine deposition. Resubmergence of the borderlands by the sea interrupted nonmarine deposition, and marine sediments were laid down over the peat.



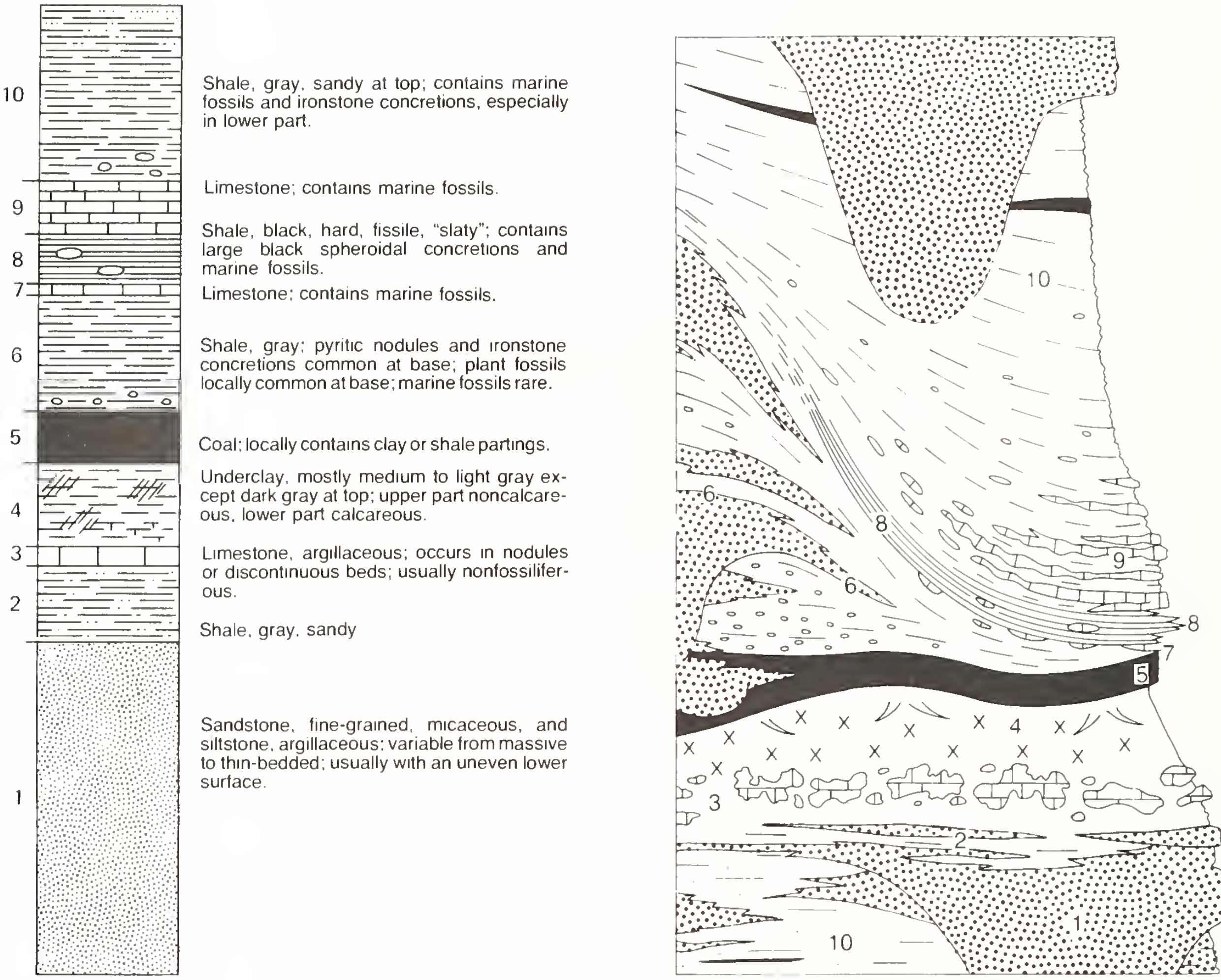
Paleogeography of Illinois-Indiana region during Pennsylvanian time. The diagram shows a Pennsylvanian river delta and the position of the shoreline and the sea at an instant of time during the Pennsylvanian Period.

Pennsylvanian Cyclothems

The Pennsylvanian strata exhibit extraordinary variations in thickness and composition both laterally and vertically because of the extremely varied environmental conditions under which they formed. Individual sedimentary units are often only a few inches thick and rarely exceed 30 feet thick. Sandstones and shales commonly grade laterally into each other, and shales sometimes interfinger and grade into limestones and coals. The underclays, coals, black shales, and some limestones, however, display remarkable lateral continuity for such thin units. Coal seams have been traced in mines, outcrops, and subsurface drill records over areas comprising several states.



General distribution of the four principal lithologies in Pennsylvanian strata of Illinois.



The idealized cyclothem at left (after Willman and Payne, 1942) infers continuous, widespread distribution of individual cyclothem units, at right the model of a typical cyclothem (after Baird and Shabica, 1980) shows the discontinuous nature of many units in a cyclothem.

The rapid and frequent changes in depositional environments during Pennsylvanian time produced regular or cyclical alternations of sandstone, shale, limestone, and coal in response to the shifting shoreline. Each series of alternations, called a cyclothem, consists of several marine and nonmarine rock units that record a complete cycle of marine invasion and retreat. Geologists have determined, after extensive studies of the Pennsylvanian strata in the Midwest, that an "ideally" complete cyclothem consists of ten sedimentary units (see illustration above contrasting the model of an "ideal" cyclothem with a model showing the dynamic relationships between the various members of a typical cyclothem).

Approximately 50 cyclothems have been described in the Illinois Basin but only a few contain all ten units at any given location. Usually one or more are missing because conditions of deposition were more varied than indicated by the "ideal" cyclothem. However, the order of units in each cyclothem is almost always the same: a typical cyclothem includes a basal sandstone overlain by an underclay, coal, black sheety shale, marine limestone, and gray marine shale. In general, the sandstone-underclay-coal-gray shale portion (the lower six units) of each cyclothem is nonmarine: it was deposited as part of the coastal lowlands from which the sea had withdrawn. However, some of the sandstones are entirely or partly marine. The units above the coal and gray shale are marine sediments deposited when the sea advanced over the coastal plain.

Origin of Coal

It is generally accepted that the Pennsylvanian coals originated by the accumulation of vegetable matter, usually in place, beneath the waters of extensive, shallow, fresh-to-brackish swamps. They represent the last-formed deposits of the nonmarine portions of the cyclothems. The swamps occupied vast areas of the coastal lowland, which bordered the shallow Pennsylvanian sea. A luxuriant growth of forest plants, many quite different from the plants of today, flourished in the warm, humid Pennsylvanian climate. (Illinois at that time was near the equator.) The deciduous trees and flowering plants that are common today had not yet evolved. Instead, the jungle-like forests were dominated by giant ancestors of present-day club mosses, horsetails, ferns, conifers, and cycads. The undergrowth also was well developed, consisting of many ferns, fernlike plants, and small club mosses. Most of the plant fossils found in the coals and associated sedimentary rocks show no annual growth rings, suggesting rapid growth rates and lack of seasonal variations in the climate (tropical). Many of the Pennsylvanian plants, such as the seed ferns, eventually became extinct.

Plant debris from the rapidly growing swamp forests — leaves, twigs, branches, and logs — accumulated as thick mats of peat on the floors of the swamps. Normally, vegetable matter rapidly decays by oxidation, forming water, nitrogen, and carbon dioxide. However, the cover of swamp water, which was probably stagnant and low in oxygen, prevented oxidation, and any decay of the peat deposits was due primarily to bacterial action.

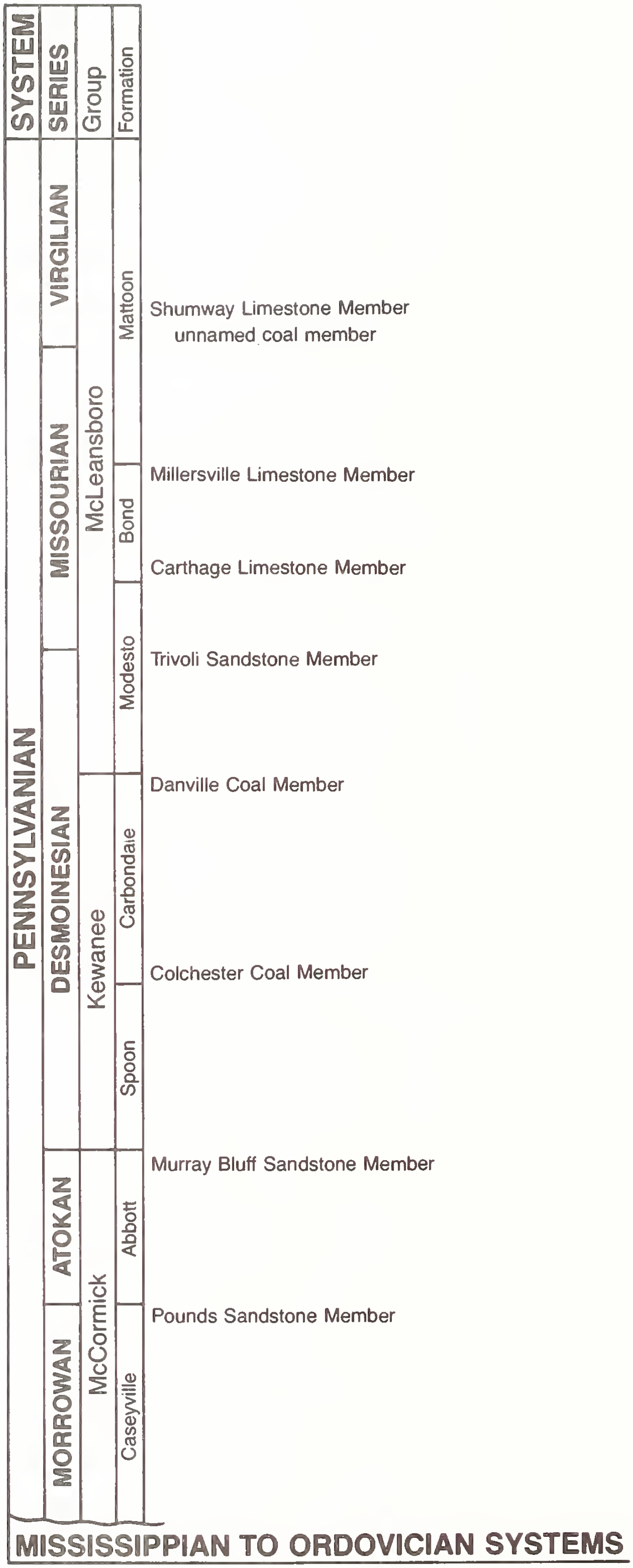
The periodic invasions of the Pennsylvanian sea across the coastal swamps killed the Pennsylvanian forests, and the peat deposits were often buried by marine sediments. After the marine transgressions, peat usually became saturated with sea water containing sulfates and other dissolved minerals. Even the marine sediments being deposited on the top of the drowned peat contained various minerals in solution, including sulfur, which further infiltrated the peat. As a result, the peat developed into a coal that is high in sulfur. However, in a number of areas, nonmarine muds, silts, and sands from the river system on the coastal plain covered the peat where flooding broke through levees or the river changed its coarse. Where these sediments (unit 6 of the cyclothem) are more than 20 feet thick, we find that the coal is low in sulfur, whereas coal found directly beneath marine rocks is high in sulfur. Although the seas did cover the areas where these nonmarine, fluvial sediments covered the peat, the peat was protected from sulfur infiltration by the shielding effect of these thick fluvial sediments.

Following burial, the peat deposits were gradually transformed into coal by slow physical and chemical changes in which pressure (compaction by the enormous weight of overlying sedimentary layers), heat (also due to deep burial), and time were the most important factors. Water and volatile substances (nitrogen, hydrogen, and oxygen) were slowly driven off during the coal-forming ("coalification") process, and the peat deposits were changed into coal.

Coals have been classified by ranks that are based on the degree of coalification. The commonly recognized coals, in order of increasing rank, are (1) brown coal or lignite, (2) sub-bituminous, (3) bituminous, (4) semibituminous, (5) semianthracite, and (6) anthracite. Each increase in rank is characterized by larger amounts of fixed carbon and smaller amounts of oxygen and other volatiles. Hardness of coal also increases with increasing rank. All Illinois coals are classified as bituminous.

Underclays occur beneath most of the coals in Illinois. Because underclays are generally unstratified (unlayered), are leached to a bleached appearance, and generally contain plant roots, many geologists consider that they represent the ancient soils on which the coal-forming plants grew.

The exact origin of the carbonaceous black shale that occurs above many coals is uncertain. Current thinking suggests that the black shale actually represents the deepest part of the marine transgression. Maximum transgression of the sea, coupled with upwelling of ocean water and accumulation of mud and animal remains on an anaerobic ocean floor, led to the deposition of black organic mud over vast areas stretching from Texas to Illinois. Deposition occurred in quiet-water areas where the very fine-grained iron-rich



Generalized stratigraphic column of the Pennsylvanian in Illinois (1 inch = approximately 250 feet).

mud and finely divided plant debris were washed in from the land. Most of the fossils found in black shale represent planktonic (floating) and nektonic (swimming) forms — not benthonic (bottom-dwelling) forms. The depauperate (dwarf) fossil forms sometimes found in black shale formerly were thought to have been forms that were stunted by toxic conditions in the sulfide-rich, oxygen-deficient water of the lagoons. However, study has shown that the "depauperate" fauna consists mostly of normal-size individuals of species that never grew any larger.

References

Baird, G. C., and C. W. Shabica, 1980, The Mazon Creek depositional event; examination of Francis Creek and analogous facies in the Midcontinent region: *in* Middle and late Pennsylvanian strata on margin of Illinois Basin, Vermilion County, Illinois, Vermilion and Parke counties, Indiana (R. L. Langenheim, editor). Annual Field Conference — Society of Economic Paleontologists and Mineralogists. Great Lakes Section, No. 10, p. 79-92.

Heckel, P. H., 1977, Origin of phosphatic black shale facies in Pennsylvanian cyclothems of mid-continent North America: American Association of Petroleum Geologist Bulletin, v. 61, p. 1045-1068.

Kosanke, R. M., J. A. Simon, H. R. Wanless, and H. B. Willman, 1960, Classification of the Pennsylvanian strata of Illinois: Illinois State Geological Survey Report of Investigation 214, 84 p.

Simon, J. A., and M. E. Hopkins, 1973, Geology of Coal: Illinois State Geological Survey Reprint 1973-H, 28 p.

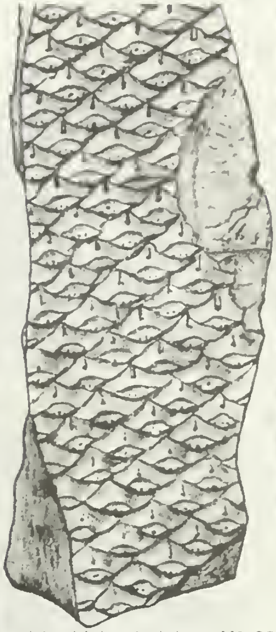
Willman, H. B., and J. N. Payne, 1942, Geology and mineral resources of the Marseilles, Ottawa, and Streator Quadrangles: Illinois State Geological Survey Bulletin 66, 388 p.

Willman, H. B., et al., 1967, Geologic Map of Illinois: Illinois State Geological Survey map; scale, 1:500,000 (about 8 miles per inch).

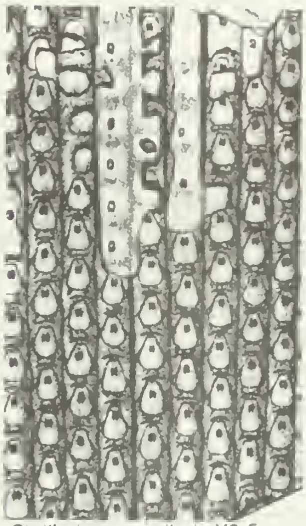
Willman, H. B., E. Atherton, T. C. Buschbach, C. W. Collinson, J. C. Frye, M. E. Hopkins, J. A. Lineback, and J. A. Simon, 1975, Handbook of Illinois Stratigraphy: Illinois State Geological Survey Bulletin 95, 261 p.

Common Pennsylvanian plants: lycopods, sphenophytes, and ferns

Lepidodendron aculeatum X0.8



Lepidophloios laricinus X0.63

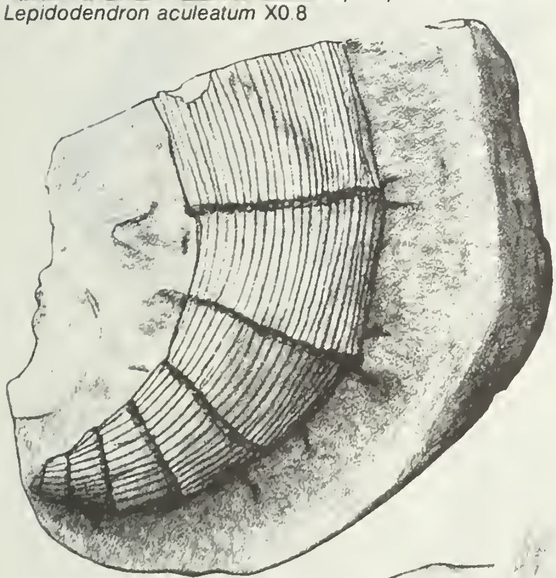


Sigillaria mammilaris X0.5

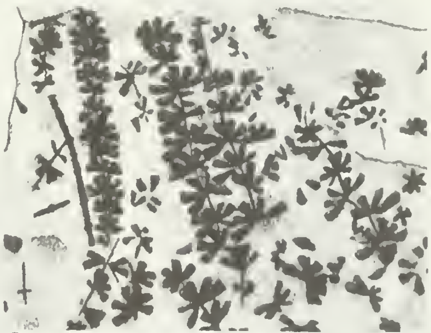
Stigmaria ficoides X0.32

Lepidostrobus ovatifolius X0.8

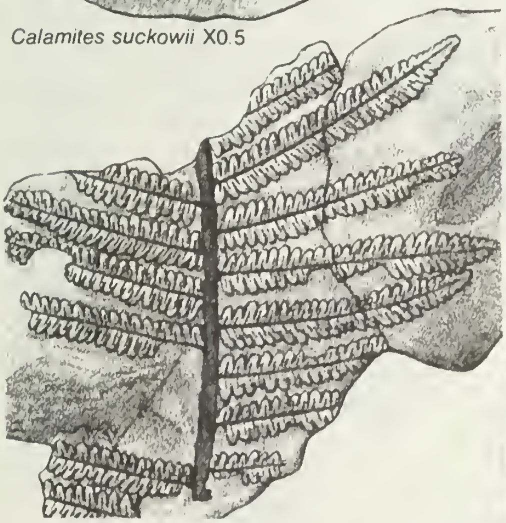
Annularia stellata X0.63



Calamites suckowii X0.5

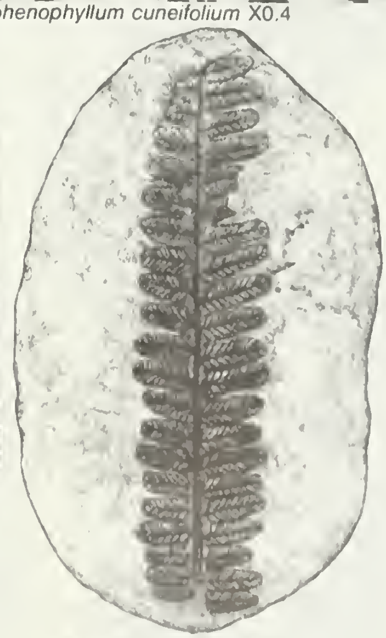


Sphenophyllum cuneifolium X0.4



Pecopteris sp. X0.32

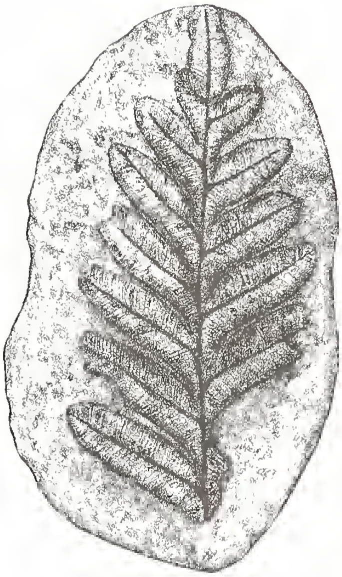
Pecopteris miltonii X2.0



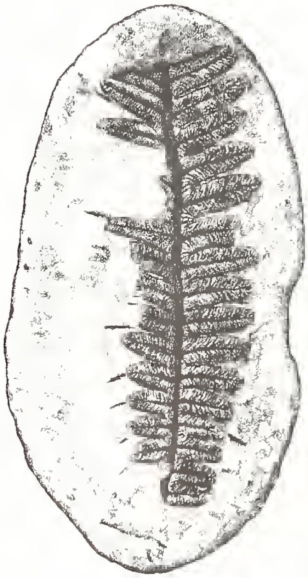
Pecopteris hemitelioides X1.0

J. R. Jennings, ISGS

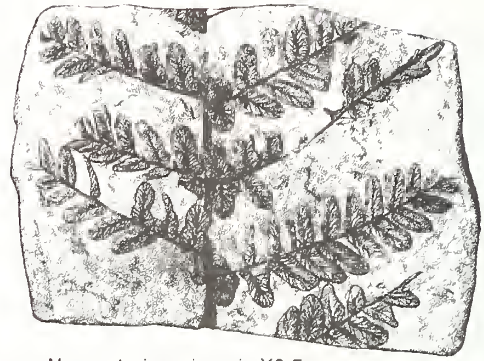
Common Pennsylvanian plants: seed ferns and cordaiteans



Alethopteris serlii X0.63

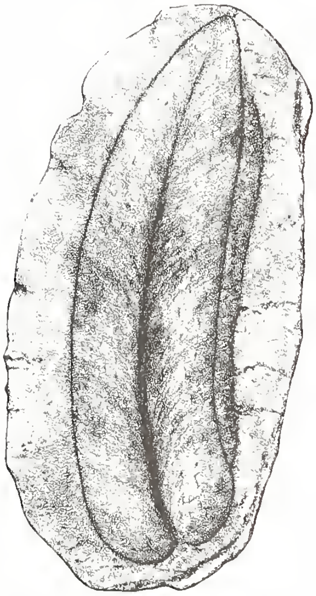


Alethopteris ambigua X0.63



Neuropteris rarinervis X0.5

Mariopteris nervosa X0.8

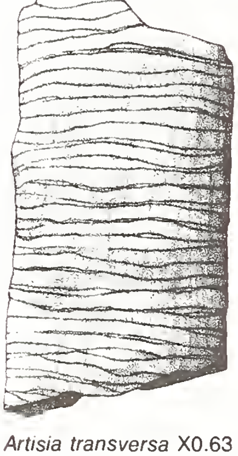


Neuropteris scheuchzeri X0.63

Sphenopteris rotundiloba X0.8

Trigonocarpus parkinsonii X1.25

Cordaicladus sp. X1.0

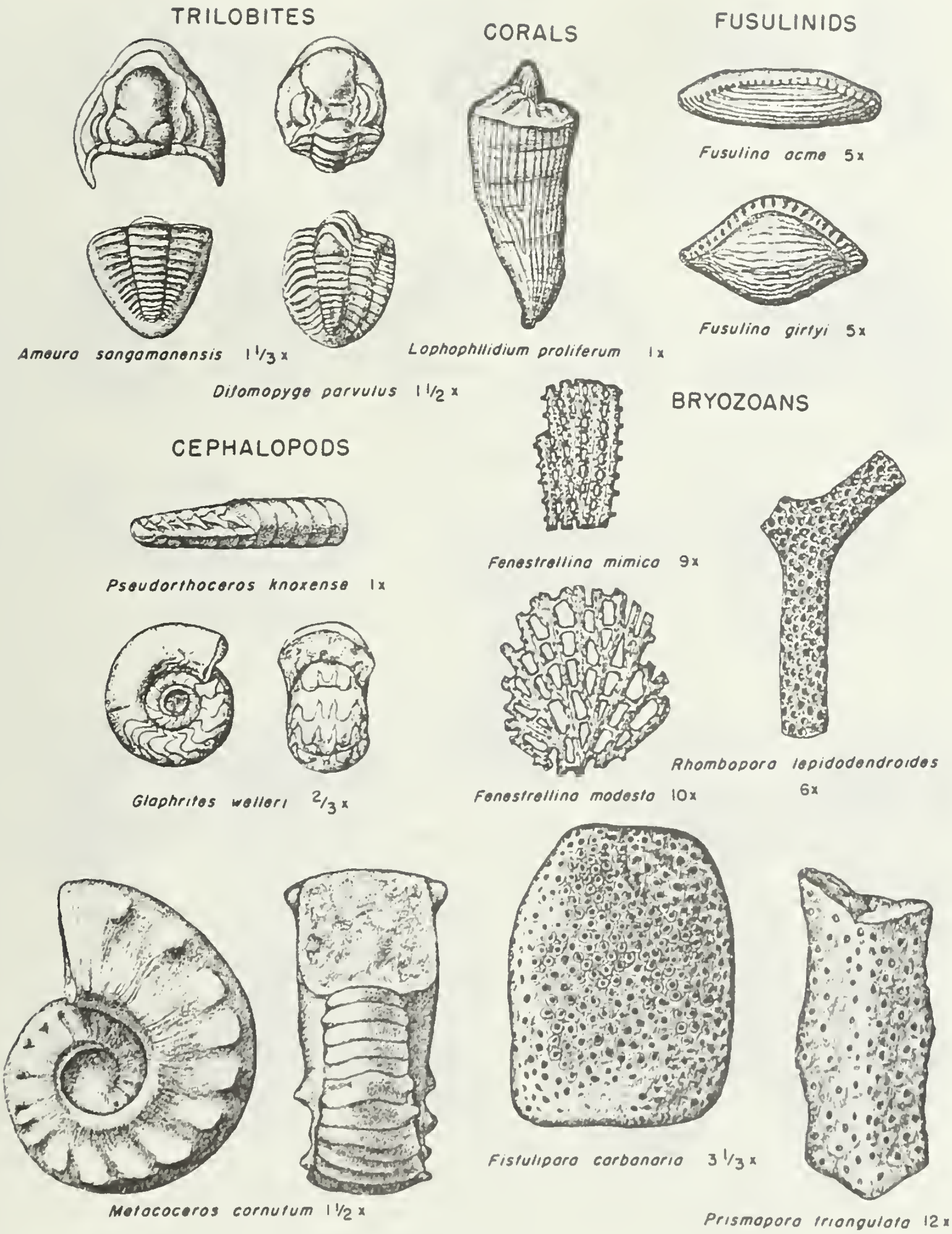


Artisia transversa X0.63

Cordaicarpon major X2.0

Cordaites principalis X0.63

J. R. Jennings, ISGS


TRILOBITES
Ameura sangamonensis 1 1/3 x
Ditomopyge parvulus 1 1/2 x
CORALS
Lophophllidium proliferum 1 x
FUSULINIDS
Fusulina acme 5 x
Fusulina girtyi 5 x
CEPHALOPODS
Pseudorthoceros knoxense 1 x
Glaphrites welleri 2/3 x
Metacoceras cornutum 1 1/2 x
BRYOZOANS
Fenestrellina mimica 9 x
Fenestrellina modesta 10 x
Rhombopora lepidodendroides 6 x
Fistulipora carbonaria 3 1/3 x
Prismopora triangulata 12 x

PELECYPODS

Nucula (Nuculopsis) girtyi 1x

Edmonia ovata 2x

Astartella concentrica 1x

Dunbarella knighti 1 1/2x

Cardiomorpha missouriensis
"Type A" 1x

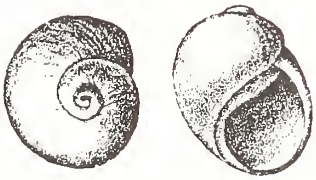
Cardiomorpha missouriensis
"Type B" 1 1/2x

GASTROPODS

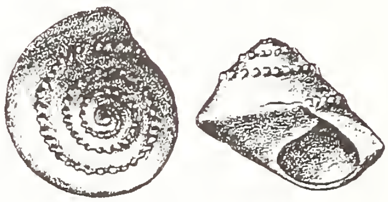
Euphemites carbonarius 1 1/2x

Trepospira illinoisensis 1 1/2x

Donaldina robusta 8x



Naticopsis (Jedria) ventricosa 1 1/2x

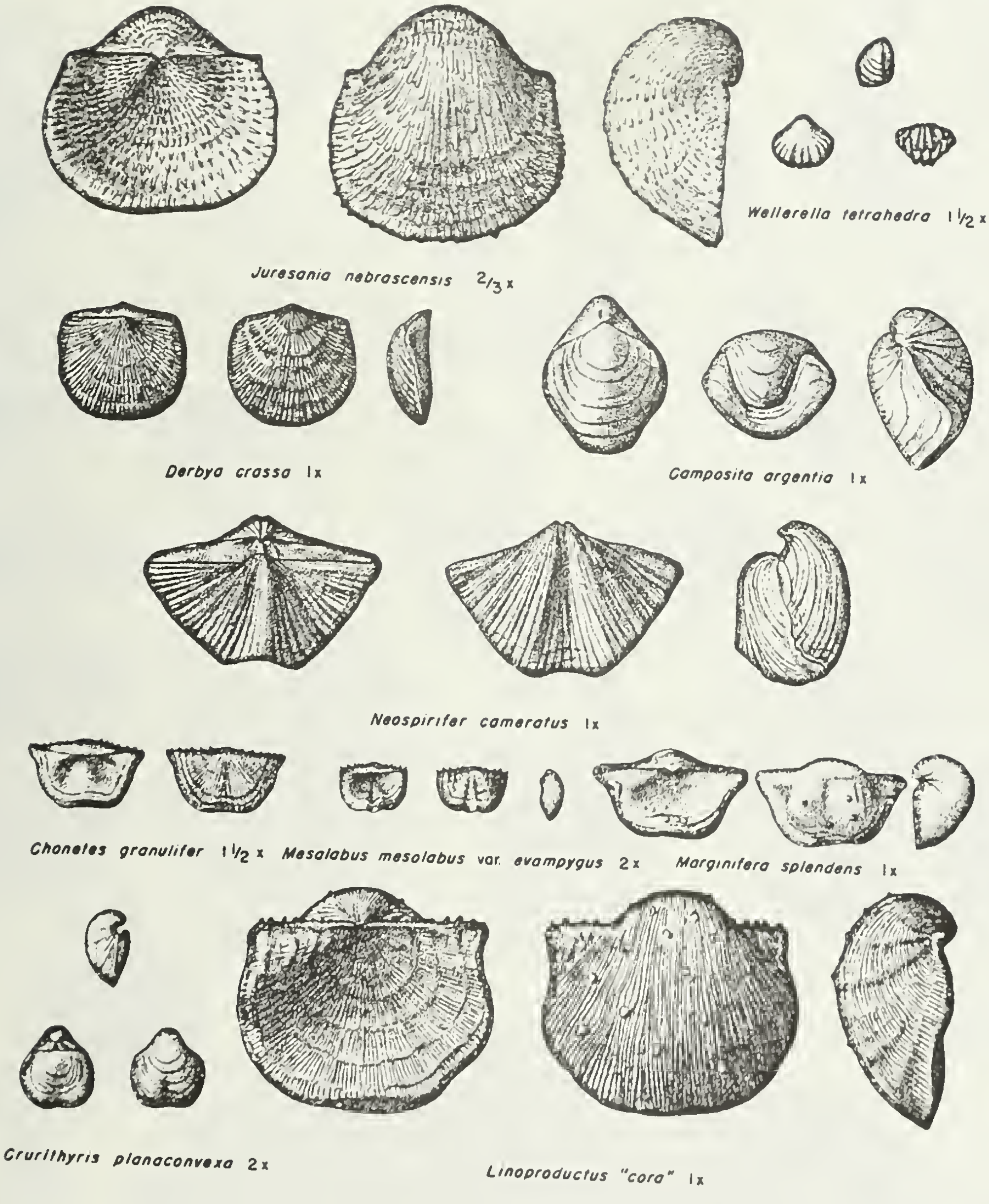


Trepospira sphaerulata 1x

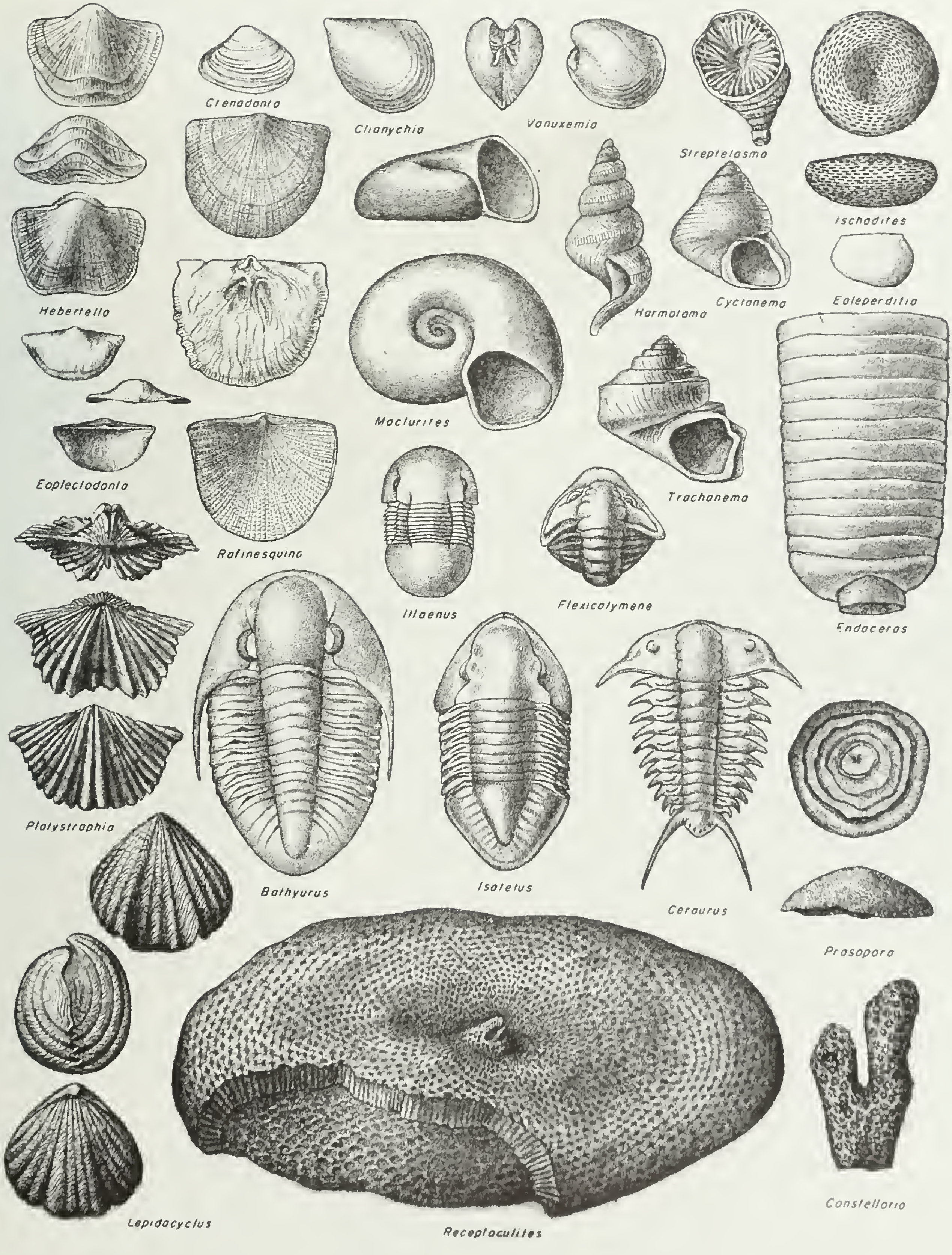
Knightites montfortianus 2x

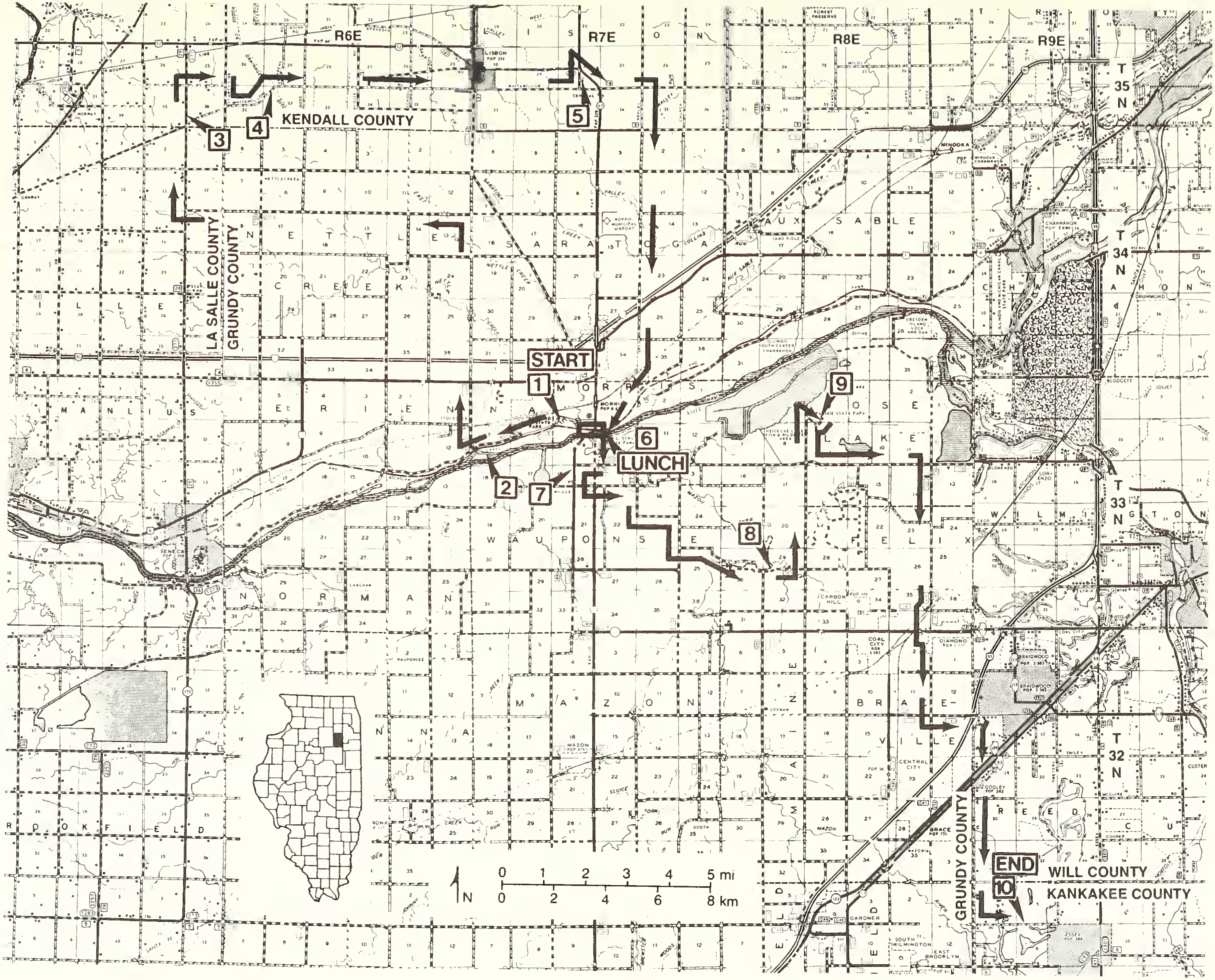
Glabrocingulum (Glabrocingulum) grayvillense 3x

BRACHIOPODS



ORDOVICIAN FOSSILS





START
LUNCH
END
1
2
3
4
5
6
7
8
9
10
LA SALLE COUNTY
GRUNDY COUNTY
KENDALL COUNTY
WILL COUNTY
KANKAKEE COUNTY
GRUNDY COUNTY
R6E
R7E
R8E
R9E
T 35 N
T 34 N
T 33 N
T 32 N
N
0 1 2 3 4 5 mi
0 2 4 6 8 km